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The Asylum Ave. Concrete Viaduct, Knoxville, Tenn.

By L. W. FRIERSON.*

The Asylum Ave. Viaduct recently completed at Knoxville, Tenn., is a reinforced-concrete structure of the girder type, consisting of three 46 ft. spans, two 48 ft. skew spans, four 23 ft. spans, and three approaches. It has a total length over all of 950 ft., end to end of approaches, with a 28-ft. roadway paved with vitrified brick, and two 6-ft. sidewalks.

The bridge spans two railway tracks and Second Creek (Fig. 2). The west end of the viaduct is so constructed as to form a "Y," the main portion of the bridge extending along Asylum Ave. to 4th St., the "Y," leading off to the left at an angle of 30°, extends into Forest Ave. at Second St. Starting at the east end, the roadway rises on a 3% grade until the west abutment is reached. Here the "Y" continues on an ascending grade of 2%, while the portion extending along Asylum Ave. to 4th St. is on a descending grade of 3.50%. There was formerly at this site an old iron structure, which extended only along Asylum Ave., was of light construction and had long ceased its usefulness in caring for the increasing traffic from the business district to Mechanicsville. The new structure now gives an outlet from the business district to both Mechanicsville and West Knoxville, by the shortest route, and on much easier grades than any now existing.

The design of each span, varying only on account of the difference in span lengths, consists of three uniformly spaced pilaster columns, carrying a transverse floor-beam, on which in turn rest the six main longitudinal girders and two shallower fascia girders that carry the floor slab. Each girder is provided with a bracket at its support and the longitudinal girders are braced by transverse girders immediately above the floor-beams and midway between the columns, as shown on the section in Fig. 3. On the long side of the two 48-ft. skew spans there are two intermediate braces, instead of the one shown in the figure. The dimensions of the members and the amount of their reinforcement are shown on Fig. 3.

Unlike most structures of this type, the upper deck, consisting of girders and floor slab, was built independent of the floor-beams or supports. This allows a free expansion of the entire deck. In constructing the main part of the viaduct, the columns and floor-beams and the brackets under the longitudinal girders were concreted in one operation. The top of the floor-beams, after hardening, was oiled with paraffin oil and the longitudinal girders and floor slab of each span were concreted in one operation. No expansion joints were made in the upper deck of the bridge except at each end adjoining the retaining walls, where a 2-in. joint is maintained between the end of the girders and the wall. Thus it will be seen that the 328 ft. of the upper deck, which consists of the girders and floor slab, is monolithic, and independent of the floor-beams and has 2 ins. at each end for expansion.

In constructing the floor slab of the viaduct, a portion of the slab 6 ft. wide in the middle of the roadway was lowered 5 ins. in order that a street car track could be laid across the bridge in the future. In making provision for the trolley poles, an 8-in. cylinder was placed in the floor-beams, every other span, on each side of the roadway. Above these cylinders the same size opening was left in the sidewalk slab.

The hand rail, the design of which is in keeping with the straight lines throughout the structure was built in place. The pilasters were built first, and each 23-ft. section of hand rail built separately, thus making a cold joint on each side of every pilaster. The light standards which are of concrete also, were concreted with the pilaster on which they rest. They are octagon shaped with a 2-in. pipe on the inside extending through the pilaster and under the sidewalk. These standards will be capped with an ornamental work of bronze, holding three 32 cp. lamps.

The two west approaches are of earth fill between two L-shaped reinforced-concrete retaining walls, buttressed every 10 ft. with 18-in. counterforts. These reach a maximum height of 34 ft. The east approach is an earth fill between non-buttressed L-shaped walls, attaining a maximum height of 23 ft. Each of these finish in the ordinary type of U-abutment. Except that the end girders are supported on pilasters incorporated in the face of the abutment as shown at the abutment on the left of Fig. 4.

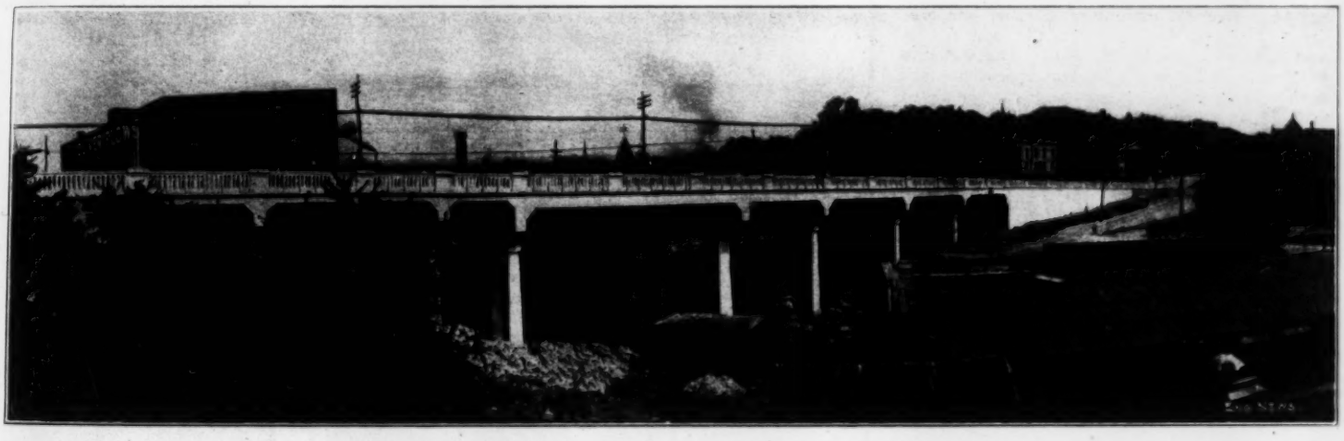


FIG. 1. VIEW OF THE ASYLUM AVE. VIADUCT IN KNOXVILLE, TENN.
(East Abutment on the Right).

The viaduct was designed for a uniformly distributed load of 150 lbs. per sq. ft. for any part of the roadway, with a factor of safety of two for dead loads and four for live loads. The sidewalk was designed for a uniformly distributed load of 100 lbs. per sq. ft., with the same factors of safety as for the roadway.

The concrete mixtures for the columns are 1: 2½:4½, and for the girders and floor slab 1:2:4. In the girders and floor slab, screening dust was used in preference to the Tennessee river sand as the dust gave better results under tests. In both retaining walls, the buttress wall of the west approach and the cantilever wall of the east approach the mixture was 1:2½:4½. The steel used throughout the structure is the square and twisted lug bar high carbon steel, with the exception of the reinforcement in the hand rail which consisted of round rods.

On account of the changing of street grades at the east end, the construction of the viaduct was begun at the west end. The retaining walls of the west approach and of the "Y," were built

*Care of Foster-Creighton-Gould Co., Louisville, Ky.

first, then the 23-ft. spans and so on until the east retaining wall was reached. The construction of the cantilever wall of the east approach was carried on during the erection of the 46-ft. spans. The erection of the falsework and the placing of the concrete in the bridge proper, was accomplished by the use of a wooden traveler, which spanned the width of the bridge. It was operated on steel rails on 12 × 12 in. stringers laid across falsework bents on each side of the bridge. On each end of the traveler was a 30-ft. boom, which was used for lifting the concrete in buckets from the mixing plant on the ground. The traveler was operated by a hoisting engine near the mixing plant.

Work was started Nov. 22, 1909, and was carried on steadily throughout the winter months, with the exception of days when concrete could not be placed on account of freezing temperature. The final work of laying the brick paving was completed August 18, 1910. The filling in with earth of the east and west approaches was done under separate contract and was completed Sept. 15, at which time the viaduct was formally opened to the public.

The structure was designed by Messrs. W. B. Crenshaw and David Meriwether of Knoxville, Tenn., and was built by the Foster-Creighton-Gould Company of Nashville, Tenn. The author was supervising engineer. The viaduct cost $47,000 exclusive of property damages and the filling in of approaches. The retaining walls cost about $20,000, which leaves a unit cost of about $2.00 per sq. ft. for the bridge proper. The expense of building the structure was shared by the Louisville and Nashville R. R., the Southern Ry., and the City of Knoxville.

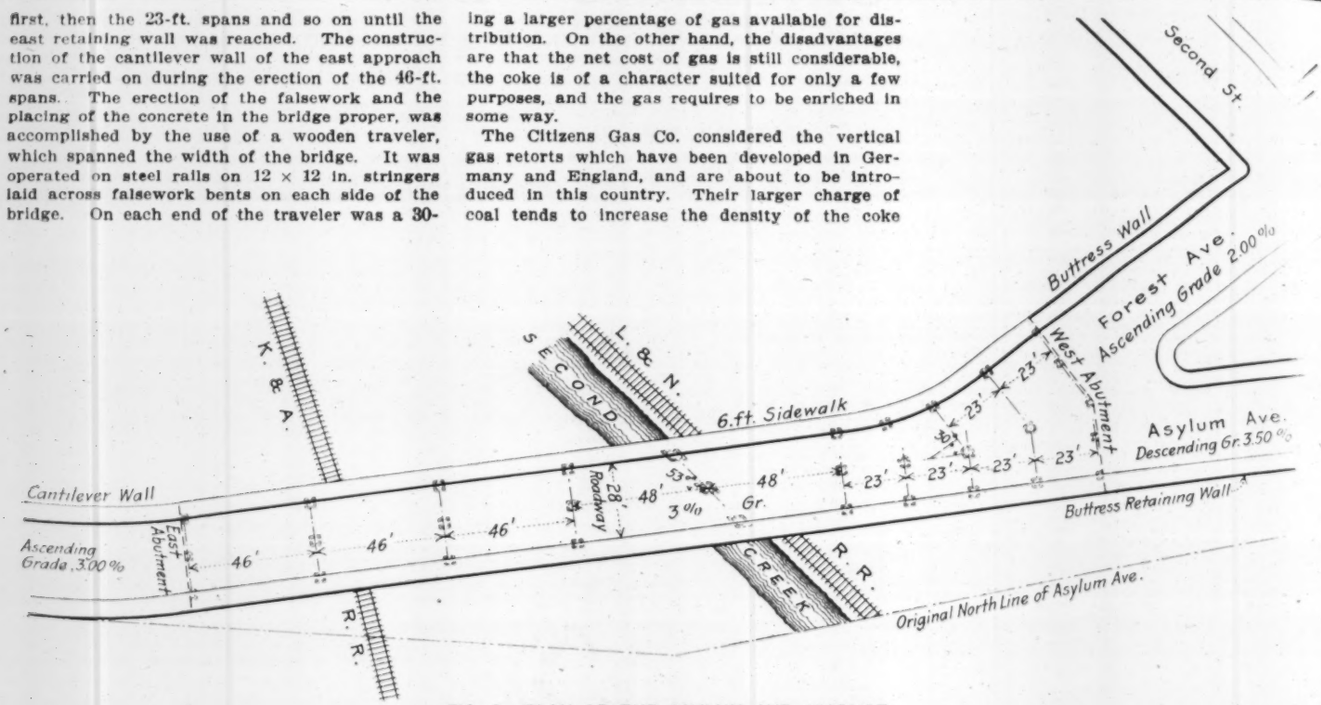


FIG. 2. PLAN OF THE ASYLUM AVE. VIADUCT.

(due to the weight of the charge); but the reduction in labor cost of charging and discharging claimed for the vertical as compared with the horizontal or inclined retort has not been established.

While the company was under the necessity of building a plant which would produce gas at a low cost, commercial conditions made it undesirable to increase the market supply of gas-house coke. Therefore, the company turned to the consideration of a process which would (1) yield by-products to offset a material part of the cost of manufacture, (2) produce gas that would not require enrichment, and (3) give coke

Manufacturing Illuminating Gas in By-Product Ovens.

The use of by-product coke ovens for producing illuminating gas has been adopted by the Citizens Gas Co., of Indianapolis, Ind., and particulars of the plant are given by Mr. J. D. Forrest (Secretary of the company) in the 1910 "Proceedings" of the Indiana Engineering Society. The company is a new one and had pledged itself to the supply of cheap gas.

In reviewing the steps which led to the adoption of the present system, Mr. Forrest states that the ordinary process for the production of carburetted water gas has the great advantage of low first cost of apparatus; but that it has the disadvantage of high cost of operation, as there are no salable by-products and the use of oil is required to make the gas of sufficient candle power. The ordinary coal-gas process has an advantage in cost over the water-gas process owing to its producing a considerable amount of by-products. In comparison with the by-product oven process, it has advantages in using up a portion of its own coke and in yield-

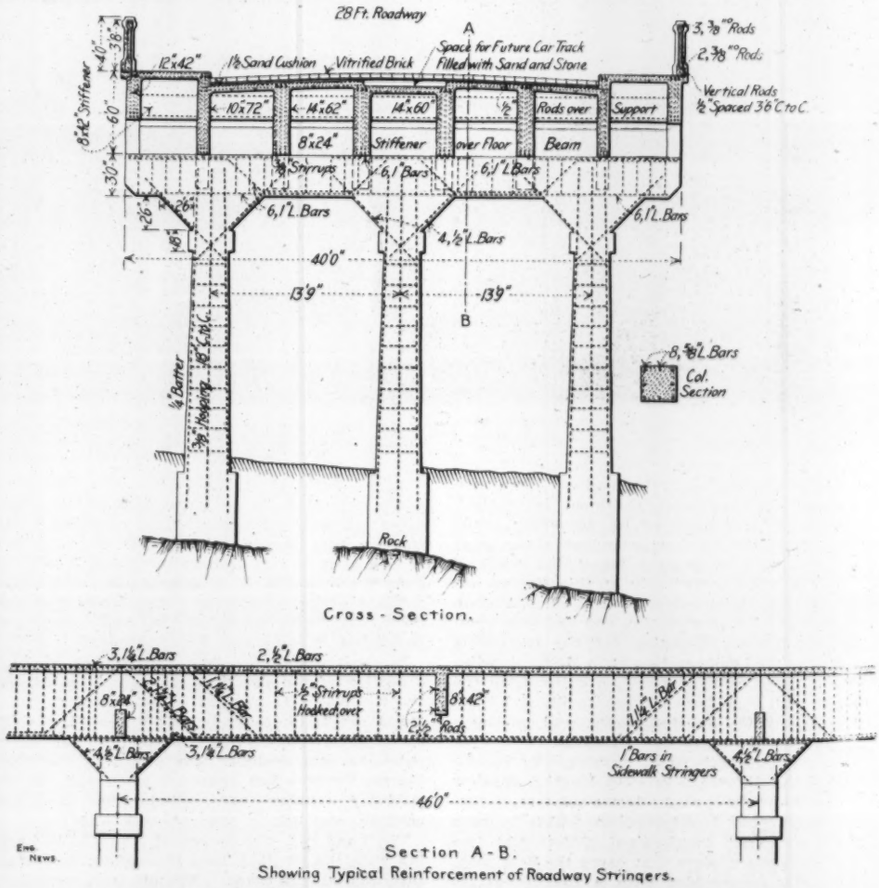


FIG. 3. LONGITUDINAL AND TRANSVERSE SECTIONS OF ASYLUM AVE. VIADUCT.

of such character as to have a wider market than ordinary gas-house coke. It was found that in some cases coke from by-product ovens was highly satisfactory for foundry and blast furnace purposes, sometimes commanding a premium over beehive coke. Further, the local industrial situation would enable the company to sell foundry coke with ease, although blast-furnace coke would not be profitable as the main output. At the same time, the culls from the foundry coke would make a better domestic fuel than ordinary gas-house coke, owing to the greater density of the former.

The United-Otto vertical-flue type of oven was selected after considering various types because (1) its construction was thought to fit it to stand the severe strains from contraction and expansion, (2) it would yield a larger proportion of suitable gas per ton of coal, and (3) it had been used for gas-making purposes to a larger extent than any other by-product oven. Each oven takes a charge of 7½ to 8 tons (as against a few hundred pounds in a gas retort). The weight of the charge tends to increase the density of the coke, and the restricted expansion of the coal in the oven also causes greater density than in the beehive coke, since there is room for expansion upward in a beehive oven. While the by-product process consumes a portion of the gas generated, it is the latter part of the gas produced, which is low in candle-power and in calorific value. The waste heat is utilized in brickwork regenerators for heating the air which is introduced into the flues to support combustion.

FIG. 4. NEAR VIEW OF ASYLUM AVE. VIADUCT LOOKING TOWARD WEST ABUTMENT.

Some particulars of the results obtained in the operation of this plant were given in our issue of Sept. 22, 1910. This showed that during the first six months of operation (working on 260 tons of coal per day) the expenditures and receipts per ton of coal were $3.276 and $4.568 respectively. It is estimated that with regular working on 375 tons per day these figures will be $4.321 and $5.315 respectively.

The following additional particulars of the plant and process are taken from Mr. Forrest's paper:

The by-product ovens are 34 ft. long, 7¼ ft. high, 16 ins. wide at the pusher end and 18 ins. at the quencher end, thus facilitating the discharge of coke made from swelling coal. There are five charging holes in the top of each oven, the middle one being the standpipe leading to the collecting mains on the top of the batteries. The ovens are built of silica brick, laid with very thin joints. All bricks were ground before being sent up to the bricklayers, and none were cut by the latter. The ovens are encased in ordinary hard red brick. The battery of 25 ovens now in use stood the heating-up process without a crack in any oven wall. The longitudinal expansion of each oven was over 2 ins. The expansion is made easy by a system of steel beams on which the ovens are built and on which they can ride on the concrete walls which support them above the regenerators.

The coal is discharged from the cars into a track hopper, from which it is conveyed to the crushing plant. This consists of a magnetic separator, a breaker, a pulverizer, and mixing apparatus. The company is using a high volatile coal in combination with a low volatile coal, and there are two bins to which the coal is fed as it is crushed. The coal from these two bins is dropped to the mixer by a device which apportions it as desired. The mixed coal is elevated by bucket conveyor to a 500-ton bin over the ovens. From this bin the coal drops into a charging larry which runs on a track on top of the ovens, and discharges the pulverized coal through its own spouts directly into the ovens.

On one side of the ovens the pushing machine is operated, and on the pushing machine is a leveling device which is run over the top of a charge before the lids are replaced on the ovens. After the coal is carbonized, a ram shoves it out of the other side of the oven in a solid block. It is shoved into a quenching car which is a very little wider and longer than the oven itself, thus permitting the coke to stand in a solid block until it is quenched. The walls of the car are heavy cast-iron plates constituting a water jacket. When the car is closed the coke is sealed as nearly hermetically as it was in the ovens. The car is run away from the ovens and the quenching takes place above a large basin which can receive the surplus water.

The water is admitted to the water jacket at the bottom and rises and flows over the top through numerous openings, thus quenching the coke under conditions which as nearly as possible reproduce those of the beehive ovens, and giving it the grey color which many of the foundry men assume to be a virtue, but which is caused merely by the exclusion of air during the process of quenching.

The bottom of the quencher car consists of a series of moveable plates and these are set in motion and discharge the coke through a chute upon the selecting platform or into the crusher. The coke which goes to the selecting platform is forked into cars, the top and end pieces being rejected and sent to the crusher, while all of the larger, hard pieces are sent out for foundry purposes. The culls are crushed and conveyed to an overhead bin into which the coke is discharged through revolving screens, and from which it is sent through chutes into the cars below.

All of the machinery used for these processes is electrically driven. The coal crusher, the coke crusher, the coke screens, as well as the charging larry, the quencher and pusher are fitted with suitable independent motors.

The ovens are divided into two batteries of 25 ovens each, and hydraulic mains descend between the two batteries. The richer portion of the gas, which is designed for distribution, is taken off through one main; the poorer gas, which is to be used for heating the ovens, is taken off through the other. Both are treated in exactly the same manner for the recovery of by-products but only the richer gas is sent through the purifiers. The poorer gas goes to a small fuel gas holder, which sends it back to the ovens for heating purposes.

The large mains which convey the gas to the condensing house are laid in an open pipe trench, in order that the gas may travel a long distance and be cooled by this means. Outside of the condensing house are large air and water coolers, which cause the gas to travel a very much greater distance before it enters the building. These coolers are provided with water connections, so that a curtain of water may fall over them when necessary, but it is only in the warmer weather that this is necessary. Provision is also made for the precipitation of tar from these coolers.

Inside of the condensing house the gas first passes through multi-tubular water coolers provided with baffles which require the gas to travel a considerable distance and which prevent short-circuiting. At this point a considerable amount of tar is drawn off. From the multi-tubular coolers, the gas passes to tar scrubbers of a special type, which, by a bubbling process, recover all of the remaining tar and a considerable amount of ammoniacal liquor. The next apparatus in the condensing house are the exhausters, which have drawn the gas up to this point and which send it forward to the holder.

Immediately beyond the exhausters are the ammonia washers, and after passing these, the gas goes direct to the purifiers. These require no special description except to mention the fact that they are entirely uncovered. They are castiron boxes with the ordinary arrangement of trays to hold the oxide in layers, and steam coils are placed at the inlet and outlet. They are elevated so that the material can be discharged by dropping and can be treated under the boxes on a concrete floor. The operating floor of the boxes, which is reached by an elevator, is of reinforced concrete, thus, together with the boxes themselves, constituting a roof over the floor. It is believed that there are very few purifying plants in this country which are left as completely exposed as this, but there has been no difficulty thus far, even with the thermometer at 8° below zero.

The storage holder is of 1,000,000 cu. ft. capacity, and since the ovens have been put in operation, it is kept at the top all the time. Gas is sent to the city through high-duty exhausters. The consumption has not yet been large enough to make the pressure a matter of much importance, but at the peaks of the load the exhausters are utilized to keep the pressure uniform. The gas distributing system is admirably adapted for high and low pressure, there being a complete gridiron of high pressure trunk lines feeding through regulators into the distributing mains. These have been put in complete condition, and as soon as conditions justify the constant operation of the exhausters, a pressure of 5 or 6 lbs. will be carried on the high pressure lines. This will be reduced in various districts to the proper pressure in the distributing mains.

As the gas is freed of tar and ammonia, these residuals are sent to their proper storage tanks. There are two large storage tanks for each by-product, and a smaller tank from which the ammonia is loaded. The tar receives no further treatment, except that it is allowed to settle, and the ammonia liquor is drawn from the top of the tank. The ammonia which comes from the condensing house apparatus is known as strong liquor, there being no necessity of a weak liquor storage tank. The method by which the weaker liquor as it is first recovered in the condensing house is utilized in the condensing house makes it possible to carry it to the storage tank as strong liquor ready for concentration. The concentration is carried on almost continuously, and when both batteries of ovens are in operation it will be quite so.

The ammonia after passing through the strong liquor tank and through the concentrator is taken to the storage tank for ammoniacal liquor ready for shipment. The apparatus can produce liquor of 25% strength or even stronger, but during the cold weather it is not possible to handle [illegible] strength of more than 16 or 18% without salting.

In addition to the plant above described, which is capable of producing 2,000,000 cu. ft. of gas per day, the company has an auxiliary water-gas plant with a capacity of 2,000,000 cu. ft. per day. This consists of two sets of the usual Lowe type, with some minor improvements. This plant has been erected as a reserve and was utilized in developing business prior to the completion of the ovens. It is not intended to be operated, but it has been made as perfect as possible, and is kept in condition for operation on short notice.

RATES FOR RESIDENCE LIGHTING based in part on actual illumination have been made by the Municipal Lighting Committee of Berlin, Ontario, the first town to receive Niagara Falls current over the transmission lines of the Ontario Hydroelectric Power Commission. A basic charge is made of 5 cts. per month per 100 sq. ft. of lighted area to which is added 4 cts. per KW.-hr. Bills are subject to 10% discount for payment within 30 days and to additional discount for payments in ten days. A flat rate of $6 per month has also been fixed for residences having a miscellaneous use of electric energy.

Double Tracking and Grade Revision on an Interurban Electric Railway.

By LUTHER DEAN,* M. Am. Soc. C. E.

The Albany Southern Ry. is an interurban electric line extending from Albany, N. Y., across a highway bridge over the Hudson River to Rensselaer, and then through a series of towns and villages to Hudson, N. Y. The total length of the route is 37.2 miles. The road is located some distance back from the Hudson River, except at the terminals. It runs through a hilly country and follows generally the natural contours of the land. As originally built it was a single-track road with turnouts some distance apart. On its private right-of-way it has an exposed third rail as the current conductor. At Kinderhook Lake (about midway between the terminals) is Electric Park, which is operated by the railway company and has a large summer patronage, especially on holidays.

Between Rensselaer and Kinderhook Lake there were several sharp curves. In October, 1909, the company decided to double-track that portion of its line, to reduce the curvature to 3° and to take out the reverse curves. It was desired to have the work completed so that the second track would be available for the summer traffic of 1910. The company employed J. G. White & Co., of New York, to do the work. A force of men was immediately put in the field under the direction of the writer, as resident engineer and construction superintendent. Final lines and grades were established and land for additional right-of-way obtained.

The subgrade work was sublet to the Elmore & Hamilton Contracting Co., which commenced excavation early in November. The lighter cuts were taken out with teams and scrapers and considerable work was done before the winter set in. The heavier cuts were taken out with two steam shovels, the material being moved by 12-yd. dump cars and steam locomotives.

The cuts were so located that it was necessary to cut out and cut in the steam shovels quite often, and without delaying passenger cars, which were run on an hourly schedule. Temporary shovel tracks were laid alongside the main track and the ends of the rails in the temporary track were placed opposite to the ends of corresponding rails in the main track. The steam shovel was moved up just behind a passenger train. As soon as the train had passed, the joints in the main track were broken and a section was thrown over and connected with the temporary track, so that the shovel could be pushed onto the temporary track. The tracks were then disconnected; the section of main track was thrown back to its original location, and the joints were rebonded and connected up. The men became quite efficient in this work and good connections were made practically every time. The section of main track was moved over and brought back at a small cost, with no material damage and without delaying regular traffic.

The work trains were compelled to keep out of the way of all passenger trains, and considerable time was taken in getting to and from sidings. But the size of the cuts and location of the fills was such that extra sidings were not warranted except in a few special cases.

There were several places where it was necessary to operate the steam shovels on the third-rail side of the main track. At these places a section of the third rail was cut out of service, and a cable was connected and carried overhead to convey the current. This cable was provided with a switch and the current was thrown into the cut-out section of third-rail by a switchman whenever a train came along. The current was thrown off again as the train had passed the section. A similar arrangement was used wherever it was necessary to dump material on the third-rail side of the track. In this way the through current was not interfered with, and the workmen were protected against danger of shock from the third rail.

The grading was carried on through a very severe winter, but there were only about three days on which the shovels were shut down completely on account of the weather. It was necessary to blast practically all of the material and the blasting was done just ahead of the shovels. Most of the drilling was done with steam drills, although some of the earth cuts were drilled by hand.

The rails for the new work were received late in the winter, and most of them were unloaded alongside of the track, so as not to require a second handling. An ordinary flat car was temporarily fitted up with a frame derrick and a hoisting engine. The boom of the derrick was of sufficient length to reach nearly to the center of a 33-ft. rail on an adjoining car. The rails were received in gondola cars and were all unloaded by this derrick car. The derrick train had to keep clear of all passenger trains, but the rails could be handled so rapidly that this work could be done between trains and make good progress.

About 3½ miles of old track (at eight different sections) was moved from its original bed in order to abolish reverse curves and to reduce curvature and grades. At two sections where reverse curves were taken out, the old and new locations crossed by a small angle at about the center of the section and it was found advisable to change the grade several feet at the crossing point. At one of these places the new grade is about 6 ft. lower than the old and at the other it is about 3 ft. higher. There was no special difficulty in raising the grade 3 ft., but cutting down the 6 ft. necessitated considerable extra work. Timbers 40 ft. long were placed under the old track at the point of intersection and these timbers were then supported by bents resting below the new subgrade. The earth was then excavated under the timbers and the second track was laid through the opening.

The angle between the two locations was so small that it was necessary at first to lay the track through the opening on a reverse curve. The third rail was carried along with the second track and was connected at both ends with the old third rail by cables. The second track was connected with the old track at the ends of the revision by switches. After the last car for the night had passed, the old track was taken up and the timbers were removed. Then the cut was widened and the second track was straightened enough to allow the first car in the morning to pass over it. The final excavation was then made and the track put in proper alinement. Fig. 1 shows the tracks before the timbers were removed.

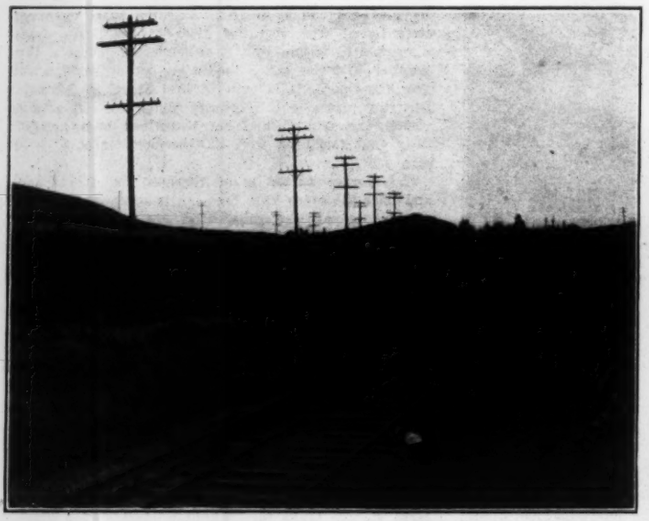


FIG. 1. GRADE AND CURVE REVISION AT ONDERDONK, ON THE ALBANY SOUTHERN RY. (ELECTRIC.)

(The new grade here is below the old grade, the old track being carried by a temporary trestle during the day. At night, the trestle was removed, the excavation completed for double tracks, and the new tracks were laid to proper alinement.)

FIG. 2. BONDING THE THIRD-RAIL ON THE DOUBLE TRACK OF THE ALBANY SOUTHERN RY. (ELECTRIC.)

(The bonding apparatus for the track rails is carried by the motor car, but for bonding the third-rail two traveling transformers were used. These have rollers riding on the third-rail and the adjacent track rail. The new track has its third-rail between the tracks, but that of the old single track is on the outside.)

At two of the villages through which the track runs it was necessary to lay the new track first on one side and then on the other side of the original track, and to cut and throw over the old track and connect it with the new. The old and new track rails were of the same section, so the track part of the work was reasonably easy. But the sections of old and new third rails were not the same, and it was necessary, therefore, to make the third-rail connection at a road crossing opening, where the two rails were connected by cable.

As the third-rail carried all of the direct current for the line it was generally necessary to keep the third-rail alive while it was being moved and while the new connections were being made. In several cases it was necessary to move quite long sections of live third-rail across the track rail, and this was done without any accidents. The men used wooden levers and kept the third-rail well blocked above the track rails.

At revisions where the old track could not be thrown to its new location with bars, temporary connections were made with switches between the old and new track, so that traffic could be cared for. The old track was broken and the rails were drawn out with a locomotive. The locomotive was switched onto the new track and the rails were pulled opposite to their new location and immediately placed. Only about every fourth joint was broken, so that four rails

*Crocker Building, Taunton, Mass.

were moved and placed at one time. In dragging the rails, special attention was given to keeping the rails away from the ends of the ties. The work was accomplished quickly and without damage to the track.

The single-track plate girder bridges were designed for a 97-ton locomotive loading. To accommodate the second track, the abutments were extended, a heavy center girder was put in, and one of the old girders was moved out to make the new side girder. The old track was supported on trestle work during the rebuilding of the bridges. The new steel for the bridges was furnished and erected by the United Construction Co., of Albany, N. Y.

The new track is laid with 80-lb. Am. Soc. C. E. rails and Continuous joints, the joints being bonded with 4/0 brazed bonds installed by the Electric Railway Improvement Co. It is laid on ties 6 × 8 ins., with gravel ballast. The ties are 8 ft. long, except that every fifth tie is 9 ft. long to furnish a support for the third rail.

The new third rail is of the 60-lb. Am. Soc. C. E. section, and is of Bessemer steel made to the the following specification (the percentages given being the maximum permitted): carbon, 0.20%; manganese, 0.50%; silicon, 0.10%; phosphorus, 0.09%; sulphur, 0.09%. The electrical resistance was estimated at 7.8 times that of copper. The rail is supported on approximately every fifth tie by a composition insulator with a malleable iron base, and every seventh insulator is an anchor. Each joint is bonded with two 300,000 cm. brazed bonds. At road crossings, the new third rail is connected by underground cable jumpers of 750,000 cm. capacity, well insulated between terminals. The cable terminals are connected with the third-rail by bare 750,000 cm. cable, cast-welded to the flange of the rail. The old and new third rails were sectionalized and cross connected at two points between the substations, and switches were installed so that in case of any trouble in one rail the section can be cut out and the other rail used for carrying the current around the section.

The old third-rail is of 80-lb. Am. Soc. C. E. section, supported by wooden insulators with malleable iron caps. It is on the outside of the track, while the new third-rail was placed between the old and new tracks. The third-rail is 26½ ins. from the gage line of the track, and its top is 6 ins. above the top of the track rails.

Two regular bonding cars were used on the work and the track rails were bonded as soon as assembled. The current for bonding was brought by a cable attached with a clamp to the old third-rail and connected with the trolley pole on the bonding car. The track rails were temporarily connected with the old track by a cable with clamps, so as to make a good return. Each car was fitted with a temporary third-rail shoe, so that it could be run on the main track. Two special transformers were used for bonding the third-rail. They were mounted on frames with rollers fitted to run on the third-rail, and the nearer track rail. They took their current from the bonding car by a cable and were arranged so as to bond on opposite sides of the third-rail. They were easily pushed along by hand from one joint to the next, but were loaded on a car if it was necessary to move any material distance. Fig. 2 shows the two transformers in position for bonding, with the bonding car beyond them.

In order to make the connections between old and new track and the different revisions without interfering with traffic it was necessary to move the bonding cars from one section of the line to another quite frequently. The cars were run on the main track under the direction of a pilot, and according to running orders issued by the regular train dispatcher. The third-rail could not be placed and bonded until after the track had been surfaced and lined. The third-rail bonding was, therefore, the last thing to be done before track could be turned over to the operating department, and this bonding was carried on both day and night whenever the conditions warranted it.

All track work and third-rail work, except bonding, was done by the J. G. White & Co. forces, and tracks were laid as soon as sections of subgrade were ready. The work was completed so that the first section of double track was turned over to the operating department for use May 29, and the remaining sections were turned over between that date and July 3, 1910.

Oil-Mixed Concrete as a Waterproofing Material.

In several issues of Engineering News* we have called attention to tests that are now in progress to determine the behavior of a Portland cement concrete to which has been added from 5 to 15% by weight of heavy non-volatile oil. A great number of these tests have been made by the U. S. Office of Public Roads in its effort to develop a mixture that would prove valuable for a road material, and would combine the strength of concrete with the toughness and elasticity of asphalt. Up to now we have never noted that this mixture has watertight qualities superior to those of ordinary concrete, but the following letter from Col. Thomas W. Symons, of the Advisory Board of Consulting Engineers of the New York State Barge Canal, to the Chairman of that Board, would indicate that such qualities may be expected in this oil-mixed concrete.

Sir: I desire to call to the attention of the Advisory Board of Consulting Engineers and of the State Engineer, a new and marked improvement in the manufacture of concrete, which has lately come to my knowledge and which I have examined into and which I believe to be particularly and peculiarly applicable to the construction of many of the masonry structures entering into the Barge Canal, especially those intended to hold water in or keep water out.

The improvement is very simple and inexpensive and consists only of incorporating with concrete as commonly prepared a certain percentage of heavy non-volatile oil, the incorporation taking place in the process of mixing the ordinary materials, cement, sand, gravel, stone and water, in the ordinary way. The result is a concrete of greater density and weight than ordinary concrete, highly repellant to and non-absorbent of water and if properly made absolutely waterproof. It is fully equal in strength to similar concrete made without oil, and in some instances has shown greater strength. This method of making oil-concrete by adding heavy oil to the common concrete aggregate has been devised and experimented with by the engineers and chemists of the "Good Roads Experimental Station of the U. S. Agricultural Department." These gentlemen are willing to place all their knowledge and experience in this matter at the disposition of the State of New York, either here in Washington or in the State.

I personally visited their laboratory, where I saw their experiments being conducted, and where I saw a large tank being built of oil-concrete, reinforced with steel rods. The reason for the greater density of oil-concrete over ordinary concrete was apparent from this work in progress. It showed the great ease with which the broken stone and mortar packed together. The oil emulsion seemed to lubricate everything in the process of packing together.

I also inspected two sections of the laboratory floor, both made at the same time; one made of plain concrete and one of oil-concrete, the appearance of both being exactly alike. Water thrown on the ordinary floor immediately penetrated into it and was rapidly absorbed, while the water thrown on oil-concrete floor stood in elevated pools and globules like quick silver, and without the slightest apparent tendency to being absorbed.

I also visited the U. S. Treasury where a number of great vaults are being constructed down beneath the grounds surrounding the building. The vaults are being built with heavy walls and roofs of oil-concrete. These walls and roofs are regarded as absolutely proof against any infiltering outside water, and as well preventing any sweating inside or dampness.

It seems to me that the peculiarly waterproof and water-repellant quality of this oil-concrete, combined with its strength and greater density renders it a material remarkably adapted to such canal structures as culverts, locks, the canal prism troughs crossing the Irondequoit Valley and the Medina Gorge, to the corewalls of earthen dams like that at Hinckley, etc.

The advisable amount of oil to use in concrete is about 10% of the weight of the cement. This amount is being used in making the U. S. Treasury vaults and gives very satisfactory results. At the Experimental Station where the process was developed experiments are being made with various proportions, percentages and varieties of oil cement.

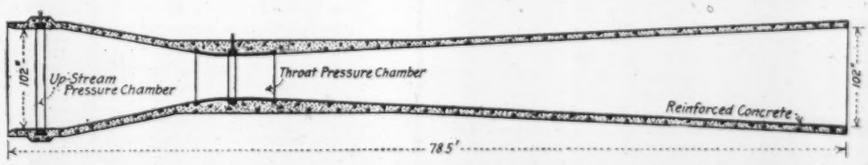
The oil costs about 6 or 7 cts. per gal. or about 40 to 50 cts. per cu. yd. of concrete for the oil. To this must be added a small amount for handling and incorporation. It is fair to assume therefore that oil waterproof concrete will cost some 60 to 70 cts. per cu. yd. more than a similar quality of plain concrete.

Thomas W. Symons.

*Dec. 23, 1909, pp. 708, 710; Jan. 13, 1910, p. 44.

A Large Venturi Meter for the Montreal Water Works.

In Engineering News, Nov. 25, 1909, we described the largest Venturi meters in the world—a pair of 120-in. tubes registering up to 625 cu. ft. per min. (404,000,000 U. S. gals. per 24 hrs.) at the Divi Island Pumping Plant, Madras, India. Up to the present, the largest Venturi tube in America has been a 96-in. one at Pittsburg, Pa., but now a closer approach to the Divi Island installation has been made here.



SECTION THROUGH 102-IN. VENTURI METER FOR THE MONTREAL MUNICIPAL WATER SUPPLY SYSTEM.

The Builders Iron Foundry of Providence, R. I., has completed parts of a 102-in. tube for a new conduit which will supply water for the municipal system of Montreal, Canada. The head is low at this point and, as the conduit is of reinforced concrete, it was decided to make the cones of the meter of the same material. The up-stream pressure chamber and the throat section are of cast iron, the latter being bronze lined. The construction is shown in the accompanying figure.

It is not expected that this meter will be required to measure beyond 70,000,000 Imp. gals. (84,000,000 U. S. gals.) per 24 hours, but if the head should be increased, to increase the capacity of the conduit, the meter will register up to 230,000,000 U. S. gals. per 24 hours.

The registering and recording attachment is actuated by floats in wells connected to the pressure pipes, similar to the Divi Island plant. The counter dial is a straight-reading type and shows total number of gallons passed. A chart recorder shows the rate of flow at all hours.

The Builders Iron Foundry has under construction the parts for a much larger meter than any yet installed anywhere. This is for the New York City Catskill Aqueduct, and it will have a maximum inside diameter of 210 ins. and a throat diameter of 93 ins.

STREET CAR FENDERS of various types have been investigated by the Board of Supervising Engineers, at Chicago, with the result that non-projecting fenders are approved for the cars of the Chicago street railways. The general results are stated as follows in the Board's annual report:

(1) It is not practicable to provide a device or fender that will prevent all injury to a person if struck by a car.

(2) A person in a standing position is bound to receive more or less severe injuries when struck by a car.

(3) The chief function of a life-saving device is to prevent the victim from getting under the wheels of the car.

(4) Efficient non-protruding fenders of practical design are on the market; they are preferable to protruding fenders where cars are operated in crowded city streets.

(5) Most important of all, life-saving devices must be carefully inspected and maintained to ensure continuous efficiency.

Is a Rational Basis Possible for Telephone Rates?*

By DUGALD C. JACKSON,† M. Am. Inst. E. E.

The question of fair telephone rates is a very complex one. It is much more complex than the question of fair rates for gas or for tramway service. A gas company has a particular commodity to sell, associated with the disposal of some by-products, to be sure, but the main object is to sell one particular commodity. A telephone company, on the other hand, must sell service, which is more difficult to accomplish satisfactorily than the sale of commodities, perhaps for psychological reasons. On account of the wide range of service that telephone companies must supply, it seems necessary to group their customers and organize the groupings on the grounds of the use likely to be made of the service. This grouping of telephone subscribers as residence, business, private-branch exchange, special-line, and party-line subscribers, etc., has become substantially universal.

I will here give my own answer to the query that is found in the title of this paper. A rational basis of rates is possible, and it primarily consists in arranging the groups of subscribers so that no group fails to bring the revenue necessary to operate its service, and so that the subscribers are so fairly associated in the groups that in none are a considerable proportion of the subscribers not self-sustaining. Both of these acquisites are commonly neglected in the rates maintained by telephone companies.

The rates charged for telephone service in all the important American cities have grown up in accordance with expediency and as the result of the judgment and experience of the telephone officials, and it is, therefore, not astonishing that the telephone companies have become accustomed to assert that rational methods of analysis cannot be applied to test the reasonableness of such rates. Ready means of intercommunication are now so essential a part of business and social life that it is equally natural for subscribers to view askance the efforts at telephone rate-making which depend only on expediency or on the judgment of certain officials. Skepticism of the fairness of telephone rates fixed in that manner has led to investigations in a number of the more important American cities and states, and has produced reports like those made by the Merchants' Association of New York in 1905, the Special Telephone Commission of Chicago in 1907, the Board of Trade of New Orleans in 1908, the Travelers and Merchants' Association of Baltimore in 1910, and the recent studies of the Commissions of the City of Los Angeles and of the states of Massachusetts and Wisconsin.‡

The activity thus stirred up seems to give promise of the general adoption of a more rational basis of charges for service. It is undeniable that the judgment displayed by telephone officials has built up their business marvelously, and has made the telephone a necessary tool of commercial and social intercourse; but the very importance thereby given to the telephone service makes indefensible any opposition to legitimate efforts to get rates on a more rational basis. Guiding principles in so complex a subject can be evolved only as the result of thorough-going statistical study of the problem.

There are four general principles that cannot be safely departed from when considering rates of a public service company. These may be stated in the following words:

(1) The company is granted certain privileges by the public for the purpose of enabling it to furnish readily some type of service to the people, and it should be expected to furnish service fitting the needs of the people; good of its kind, and at prices which are reasonable when judged by the conditions.

(2) The company must not be unnecessarily harassed, but must be afforded reasonable opportunity for economically transacting the business related to giving the service for which the company was organized; and it must be allowed to make sufficient returns on its investment to enable it to attract the best and fairest minds to the management, and maintain a position of stable credit with the investing public.

(3) A public service company in a new and developing country must see before it opportunity to earn returns on its invested capital which are large compared with those adequate in stable and thickly-settled regions, in order that it may secure the capital needful for developing its plant and extending its service to meet the apparent needs of an expanding but not yet stable population.

(4) A new company, even in a stable country, ought to earn more than current rates of interest for its investors whose enterprise enables them to take the risks of establishing the business, but the rate of return on the investment may be expected to approach current rates of interest after the business has become profitable and is firmly established on fixed franchise rights covering a long period.

An acceptance of those general principles, leads as a consequence thereof, to recognizing that an equitable system of telephone rates should distribute the burden of expense of operation, maintenance, depreciation and interest, reasonally among the users.

The ideal method of charging for telephone service is (1) to charge each customer in proportion to the service he receives from the company, measured in quantity received and of the quality corresponding to his needs; and (2) to make the charge to all customers as low as is consistent with the operation and maintenance of the property, accompanied by the payment of a fair return on the money invested.

When flat or unlimited-service rates are charged, two kinds of customers, namely, business customers and residence customers, are ordinarily differentiated from each other. Each of these kinds may be grouped in various classes by arranging individual subscribers on special lines, by associating two or more subscribers on a party line, by providing private-branch exchanges, etc., according to the needs of the customers. The rates charged for service in the several classes may be expected to differ, on account of differences in the cost of equipment required in different classes and on account of differences in the average amounts of use by customers in different classes.

Message rates for telephone service have decided advantages over flat rates in many particulars. Message rates manifestly make it possible to reduce the price of telephone service to the small users to the smallest fair annual charge for what they actually receive.

The smallest fair annual charge referred to is one that is sufficient to cover a reasonable interest and depreciation and maintenance for the portion of the plant that must be provided for the use of the average of the individual users in the subscriber's particular class, added to an amount which is proportional to the average number of messages transmitted from his telephone in a year.

All legitimate expenses of the operating company must obviously be provided out of the revenue obtained from the rates, and the rates should raise only enough revenue to meet these expenses, provided the word "expenses" is used comprehensively so as to include returns on the investment. The expenses may be grouped as executive (general), operating, maintenance (repairs), taxes, renewals (depreciation), and the return on the investment. The last item is sometimes referred to as "interest" and sometimes as "interest and profit." In the latter phrasing, I presume that the interest referred to must be taken at current rates for secured investments, and that any additional return required to support the solvency of projects referred to in the third and fourth of the above mentioned general principles, may be called the "profit." A reasonable standing surplus is needed as a reservoir to maintain a parity of conditions from year to year, and if this has been drawn upon it must be replenished as earnings warrant.

If the rates by which the revenue is raised are to be put on a rational basis, there must be some better reason for the differences between the charges for different classes of service than the best judgment of company officials, however able and experienced those officials may be. These differences now rest almost altogether on expediency, on what the traffic will bear as shown by the growth of the service, and a certain bulk judgment of the possibilities. To improve on this, it is necessary to obtain an intimate statistical knowledge of the traffic of each class of subscribers, the plant investment required to provide that traffic, the effect of the traffic on the wear of plant, the expenses of operation associated with the traffic, and other like information that telephone companies have not been in the habit of gathering or recording. The plant, the money, and the traffic statistics must be brought into association.

The telephone companies have heretofore been satisfied to hold their accounting as a species of auditing capable of showing what dividends the company can pay after leaving some surplus as the result of any year of operation, and they have failed to erect it into a statistical structure which will afford indications of the relative reasonableness of their different rates. The hesitancy of company management to enter upon full statistical records and study of its business when not compelled to do so by the influence of keen competition such as exists in some branches of manufacturing, is perhaps not unnatural, but it is a hesitancy that needs to be overcome for the joint good of the public and the serving companies.

As a basis of determining the reasonableness of rates, the following factors must be taken into account: (1) the annual cost entailed by the investment which is needed to care for the subscribers' wants (which investment depends not only on the cost of the plant required to connect the subscribers to the exchanges, but also on the amount of traffic which is handled over the subscribers' lines) and (2) the cost per message entailed in caring for the subscribers' traffic.

The property required for each class of service must be maintained day by day, and also must be replaced as it depreciates from any cause below an efficient condition. Interest must also be earned upon the investment. These should not be apportioned among the classes of service directly in proportion to the numbers of subscribers in the classes, but should be apportioned in proportions depending jointly on (1) the numbers of subscribers, (2) the character of the plant required, and (3) the amounts of traffic in the several cla[sses] annual cost entailed by the investment which is [needed] to pay for the subscriber's wants, therefore, dep[ends upon] two things: One is the mere fact of his taking [service], service, and therefore requiring the company [to furnish] equipment whereby it may be ready to serve [him], the cost of which equipment is affected by the k[ind of service] he subscribes for, as special line, two-part[y], branch exchange, etc. The other is the ext[ent of his] traffic, since a large amount of service origin[ating] in a subscriber calls for a larger investment in cer[tain] portions of the plant than would be requisite to car[e for] the wants of a subscriber with a similar line bu[t smaller] traffic thereover.

The costs over and above the return on the [invest]ment are made up of (a) an operating cost, [including] the costs of general expenses (including taxes), sup[erint]endence, advertising, current repairs, instrument [rentals], messenger expense, conduit, pole and roof rent[als], sublicensee expenses, and the like, and (c) the depr[eciation] charge.

The investment required per subscriber in the various classes of service is a complex quantity. For instance, each subscriber requires one substation and one drop wire, regardless of the character of service. Special-line subscribers each require one subscriber's telephone circuit with switchboard connection. Party-line subscribers are each chargeable with a part of the cost of a one-subscriber line, switchboard connection, etc.

Interest and depreciation (renewals) carry a larger influence in the affairs of a public service company than in average business affairs, particularly because the total income of a public-service company is a fraction of the actual money invested instead of being a multiple thereof. It is, therefore, manifest that a detailed knowledge of the cost of producing the property required for sustaining the public service is one of the features of prime importance in the problem of arriving at rational rates. This points to appraisals of the property of the telephone companies, as done in Massachusetts and Wisconsin, since the companies themselves seldom have adequate records of either property units or property costs.

The apportionment of investment and annual expenses between classes of service for the purpose of testing the reasonableness of existing rates or for fixing new ones, requires the assumption of factors and the utilization of averages which the old type of telephone man may criticise, but such criticism may be more captious than just. The whole fabric for instance, of charges for insurance depends upon careful actuarial computations founded on the use of averages and it works out advantageously for both the insurer and the insured. A careful insurer would have a profound distrust of an insurance company which failed to gather, record, and use all pertinent statistics in connection with its rate making.

One of the difficulties of the telephone situation is to devise a test of the equitableness of rates which, as a test, will be satisfactorily applicable to all cases. It is being urged in some quarters that cost of specific performed service shall be determining. In other quarters, it is urged that the "value of the service" to the subscribers shall be determining. The latter seems but another way of proposing to make charges according to "what the traffic will bear," when that phrase is used in its objectionable sense of taking as much as the subscribers will give up. This phrase, "what the traffic will bear," however, has a meritorious significance which differs from its popularly accepted meaning of taking all that the customers will pay. According to its meritorious and correct meaning, it signifies that the charges made for service are adjusted as between the company and each of its customers, so that (1) the company finds the dealings profitable with each, when the full situation is considered, and (2) each customer receives service which, as nearly as practicable, meets his requirements and costs a price which makes the service advantageous to him, while (3) no unjust discriminations between customers are allowed.

In passing, I will make a note that the last phrase does not involve equal prices to all customers, but does involve the treatment of all customers so that they obtain from the company relatively a full return for their money.

It seems to me that the test of the reasonableness or equitableness of the rates maintained by a public-service corporation is found in: (1) The effectiveness and simplicity with which the schedule classifies the customers, so that the total required income is collected in a manner which secures the same rate for all customers of a class obtaining approximately like service, though customers belonging in different classes may be subject to quite different rates because they obtain service with differences of character which essentially affect the cost per unit, and (2) the certainty with which the rates secure from each class of customers the full annual operating cost of the service to that class and such a proportion of the reasonable return on the investment as the customers' traffic can afford.

It then becomes a matter of public policy to determine whether a company receiving a public grant shall be privileged to take a larger proportion of profit from one class of customers than from another, the word "profit"

*Extracts from a paper before the National Municipal League, Buffalo, N. Y., Nov. 15.

†Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass.

[‡The Massachusetts investigations were presented at length in Eng. News, Oct. 20, 1910, pp. 411 and 421. In the issue of March 24, a short article described the Wisconsin studies into quality of service.—Ed.]

being used to signify the aggregate return on the investment. This is a relatively new question in public policy, and the ultimate limitations of the policy must rest with experience and the future expressed judgment of our most judicial minds. It would be a manifest injury to the nation if the policy became so circumscribed that the railroads would feel that equal proportions of profit must be earned on all parts of their systems and from all kinds of traffic. What the effect of such circumscribed an answer would be in the case of corporations giving service within the limits of a single city or a single state like most of the telephone companies is not so clear.

The cost of performing the service seems to me the most important factor in determining rates, but its application to telephone service must be made with a cautious consideration of all the facts. Reasons for this are obvious when the problem of telephone service is carefully scrutinized. For instance, in city service, the large business users demand a celerity and accuracy for the service which adds much to its cost. Physical conditions prevent providing this fast service for one class of subscribers and not for others in intimate intercommunication therewith. But some of the latter classes, as for instance, the residence users of moderate means, may not care for the remarkable speed and accuracy which characterizes the telephone service of many American cities. Service of a lower grade of speed and accuracy, which is less costly to produce, would equally well satisfy the desires and needs of such subscribers. A distinction should, therefore, probably be made in class rates, so that the cost of the extraordinary speed and accuracy may be placed on the classes of subscribers who demand it. A similar condition exists in the relations of city and rural telephone service; it is obvious that the cost of performing specific service in the suburban communities may not always be a fair basis of rates in case the cost is to be put where it belongs.

The foregoing indicates that city business rates may be reasonably expected to be higher than residence or rural rates. A differentiation between business and residence users under flat rates has heretofore been common, and this is additionally justified by the lower average calling rate which is usually characteristic of residence subscribers where flat rates are in vogue. The relations pointed out above apparently justify an adjustment in favor of residence users of moderate requirements even when measured rates are adopted. The policy of some telephone companies apparently is in this direction, although those companies have endeavored to support their policy on the untenable theory of charging in proportion to what the traffic will bear.

Progress is plainly being made in the direction of rationalizing telephone rates. One of its indications is found in the syllabus of an opinion delivered in a telephone rate case by the Wisconsin Railroad Commission, which says:

> No reasonable objection can be taken to a schedule of rates based upon the actual quantity of the service rendered.
>
> It would be difficult to quarrel with this, provided "quantity" is construed to comprehend both the number of messages and the distance of the message transmission; it being understood, however, that any comparison must rest between users needing service of equal quality. If the latter condition is not tacitly understood, the statement ought to be amended so as to read:
>
> No reasonable objection can be taken to a schedule of rates based upon the actual quality of the service required and quantity rendered.

To show the tendency toward rationalizing rates, I will also quote from a recent finding of the Massachusetts Highway Commission in respect to telephone rates in the large city of Boston and its surrounding important suburban district.* Knowing that a certain revenue must be raised the Massachusetts Commission has pointed out,

> That the district to be covered by a given telephone rate should be the territory generally used by the great majority of the subscribers therein, rather than a much larger territory, the greater portion of which is seldom used by the majority of subscribers.
>
> That the company should collect its revenue for calls between more distant portions of the territory from those who make use of such service, rather than from those who use only local service involving the use of a much smaller portion of the plant.
>
> That the suburban exchanges have of necessity so much occasion for calling into Boston and vice versa that the 5-ct. toll rate between Boston and suburban exchanges should be extended to cover the longest distance consistent with a well-balanced schedule and with fairness to the company.
>
> That business service, at least, except for essentially local service, should be placed on a measured basis.
>
> That so far as it is possible to do so, the rate schedule should be so made as to furnish telephone service to the small user at the lowest yearly charge that is fair and equitable, and, on that as a basis, adjusted to meet the requirements of the medium and larger user.

Telephone companies still assert that no rational basis for telephone rates can be found. A few have adopted their rate schedules to the result of certain actuarial operations, but most of them have arrived at their schedules by the path of expediency and gradual modification. Few can support the reasonableness of their schedules on a foundation of facts produced from their accounting records, but I believe that this condition not only ought to be overcome, but is likely to be overcome. For willingness of the telephone companies to operate with supervisory commissions, in gathering and to some degree in studying cost and traffic statistics, is an encouraging indication. With accumulating statistics which give a clearer understanding of costs of giving service and the relation of speed and accuracy of service to its costs, each modification of rate schedules under the supervision of wisely constituted commissions ought to approach closer to a rational basis. A more effective organization of cost keeping than has yet come into vogue should be insisted on. It must also be constantly remembered that traffic is a factor of the utmost importance, and traffic statistics must be made of record and carefully studied.

The telephone rate problem seems as complex as any facing public-service commissions, not excepting the problem of railroad freight rates; but telephone rates are usually made for the territory of an individual city, or, at most, an individual state, which gives ground for expecting more rapid progress in improving the basis of fixing telephone rates than can probably be reasonably expected for freight rates.

[*See Eng. News, Oct. 20, 1910, pp. 411 and 421.—Ed.]

A Proposed Platform of Principles Governing State and Federal Control of Water Power Development.

There has long been controversy among those who stand for public regulation of water-power development, as to whether the State Governments or the Federal Government should take the chief responsibility, and as to where the line between the two should be drawn. That the line should be a clear and definite one is conceded by all, in order that there may be no twilight zones, within which the two jurisdictions may clash.

A plan on which it is to be hoped general agreement may be reached has been drafted by Mr. Philip P. Wells, formerly Law Officer for the U. S. Forest Service and now Counsel for the National Conservation Association. He has aimed to make a compromise to which both sides of the water-power controversy may agree and which will protect the public interest and at the same time encourage the development of the many millions of horsepower now unused in the mountain streams of the far West and the great rivers of the East.

The proposed plan has been laid before competent engineers of wide experience in water-power development and officers and managers of hydro-electric power companies, who have criticised it and approved it.

The basis of the plan is development without delay, waste or the sacrifice of other and higher uses of flowing water. For this, the plan holds, private capital must be aided by the state or nation through corporate franchises, condemnation of private property and licenses to use public lands and obstruct public waters, etc. Under the plan, the power companies are to have certainty of tenure for a reasonable time, and a chance for generous profits upon their actual investment. For the public, the plan promises good service, fair prices, full publicity as to cost, honest capitalization and fair rentals for public property used by the companies.

It is conceded in the plan that the Federal Government has no jurisdiction unless its land is to be occupied, or navigable rivers affected. Even in such cases the regulation of service and prices is to be the function of the state.

The platform of principles is as follows:

I. Water power development should be:

1. Prompt. Power sites should be developed, not held unused for speculative purposes.
2. Complete. Cheap and partial development for large and quick profits should not take place so as to prevent full development for moderate profits. The rich cream should not be skimmed and the milk thrown away.
3. Orderly. Every stream is a unit from source to mouth. It should be applied to human needs (potation, navigation, irrigation, power, etc.) in such order of preference or in such combination as will be of greatest public benefit.
4. All the above standards should be reasonable in view of economic conditions and business possibilities.

II. Private enterprise is not sufficient of itself to assure to the public such development as is outlined above. Public aid is needed in one or more of the following ways:

1. Corporate franchises. Especially the perpetual succession and limited liability incident to the modern corporation.
2. Authority to use private lands without the owner's consent, if consent is refused. (Eminent domain.)
3. The same as to private water rights.
4. Authority to use publicly owned lands.
5. The same as to water rights in public ownership.
6. Authority to obstruct navigable rivers.
7. Authority to assess the cost of water storage upon the lands specially benefited thereby. All power sites below the reservoir are so benefited.
8. Public construction, ownership and operation of storage reservoirs with like assessment of the special benefits. (This is the New York plan.)
9. The public construction, ownership and operation of transmission lines. (The Ontario Power Commision plan.)

III. In seeking such public aid the water companies may rightfully demand:

1. Certainty of tenure. Leases and franchises should be irrevocable, except for a breach of condition, for a fixed term of years.
2. Reasonable certainty as to the burdens (rentals, etc.) assumed by the company. (Some men of experience in hydroelectric development say it is entirely practicable to have rental value readjusted by agreement every ten years and, in default of agreement, by arbitration. Such conditions are, they say, common in leases of privately owned real estate.)
3. Adjudication of differences by an impartial tribunal. The courts should pass upon forfeitures and other penalties for breach of the conditions of the franchise.
4. A fair chance for a generous profit on the investment. This will encourage development.
5. To these should be added: fair compensation for permanent works taken from the company at the expiration of its franchise, lease or privilege.

IV. As its part of the bargain the public may rightfully demand, in addition to prompt, complete and orderly development:

1. Efficient service.
2. Equal service to all like consumers without discrimination.
3. Fair prices to consumers.
4. A reasonable time limit for leases, franchises and privileges.
5. Accurate information as to costs and profits.
6. Honest capitalization on the basis of cost.
7. Fair rentals for public property used. Rentals will not increase the cost to consumers because: (a) The share of rental chargeable against each consumer would be too infinitesimal to affect him individually; (b) prices to consumers are, in the absence of public regulation, roughly fixed by the competition of steam plants, actual or potential.
8. Continuous operation of the plant. There should be no artificial limitation of output to raise prices or restrict service. Good business policy might secure this result without regulation by the public.
9. A veto power on all assignments of privileges. Such assignments and the combination of separate enterprises by tying together several different power developments to serve a single territory are often advantageous to the public. They will sometimes present new problems and require new conditions to protect the public interest.

The standards of fair profit, efficient service, fair rentals, etc., to be applied within III. and IV. (above) will vary according to the engineering and economic conditions (including the risk) in each case.

V. What are the respective spheres of the state and federal governments in securing for the public such development and other advantages as above set forth?

The Federal Government cannot act at all except in cases over which jurisdiction is granted to it by the Constitution. It has such jurisdiction over power sites owned by it as part of the public domain, national forests, national parks and other reservations. It has some jurisdiction over the damming of navigable streams and the creation of storage reservoirs at their headwaters. The exact limits of its powers as to navigable streams are disputed as a matter of law. But the federal jurisdiction, whatever it may be, should be exercised in every case falling within it for the attainments of some, at least, of the public objects above set forth.

The practice of our government, the habits of our people and other considerations of public policy make the state governments better instruments for obtaining others of those public objects even in cases where the federal jurisdiction is unquestioned. Without attempting to mark the respective limits of federal and state activity in this behalf, it is here suggested by way of example that the United States in leasing a power site on the public domain, might properly require prompt and full development, fix a reasonable time limit for the privilege, require accurate information as to costs and profits, fair rentals for the public land used (what part of these should be paid by the nation to the state is another question) and the continuous operation of the plant (if this needs to be required at all); also retain a veto power on assignments of the lease.

All information gathered by the federal government should be available to the state government, which might, through its public service commission, or otherwise, require efficient service, equality of service and fair prices to consumers. The orderly development of the stream and the checking of over-capitalization might require action by both governments, preferably, in cooperation. Violation of the states' requirements should afford ground for the cancellation of the federal lease.

Power developments which are not on lands owned by the United States and do not affect navigation are wholly in state jurisdiction, and as to them the state governments should secure all the public objects set forth above. They should also favor development (not speculation) and reasonable public control, by good water laws and by public storage reservoirs constructed by the state at the expense of power site owners on the streams below, as proposed by the New York Water Supply Commission.

A Reinforced-Concrete Water Tank with Dome-Shaped Bottom.

By L. A. WATERBURY,* Assoc. M. Am. Soc. C. E.

The University of Arizona is located at Tucson, Ariz., but outside of the corporate limits of the city. The water required for use on the campus, including that which is used for irrigation, is supplied by a pumping plant located upon the grounds. The water which is used for irrigation is pumped directly into the ditches, supplying the various parts of the grounds, and the water which is required for other uses is pumped into an elevated tank, connected with the water mains. The tank now in use is a reinforced-concrete structure 40 ft. in height and 25 ft. in diameter, with a capacity of approximately 60,000 gals.

Fig. 1. Concrete Water Tank on Campus of University of Arizona.

The water tank consists essentially of a vertical cylinder and two domes (Fig. 2). The lower half of the vertical cylinder forms the tower which supports the tank proper, and the upper half of the cylinder forms the outer wall of the tank. The lower dome forms the bottom of the tank proper, and the upper dome forms the roof of the structure. A projecting band encircles the cylinder along the springing line of each dome, each band containing the steel reinforcement required to resist the adjacent dome. The thickness of the cylindrical shell is but 4 ins., and it has no buttresses to assist in carrying the load. The thickness of the lower dome is 4 ins. and of the upper dome 3 ins., except near the springing lines, where the thickness is increased, as shown by the half section in Fig. 2.

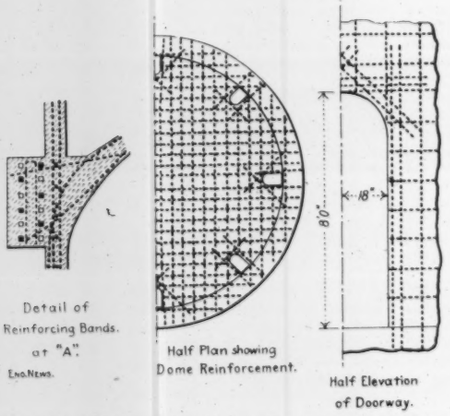


Fig. 3. Details of the University of Arizona Water Tank.

The lower portion of the cylindrical wall is penetrated by one doorway and seven small window openings. The space enclosed is at present utilized by the Department of Buildings and Grounds for the storage of materials, but it may be used in the future for shower baths to be required in connection with a swimming tank which is proposed to be built adjacent to the water tank.

The upper dome has nine openings, eight of which are screened vents, and one is a manhole, closed with a concrete cover. A steel ladder upon the outside of the tank and one upon the inside are provided leading to the manhole. The vent openings were formed by setting in place a length of 8-in. concrete pipe for each opening, before the dome was cast. The screens are held in by iron rings which were crowded into place with the screen crimped around the edges. The lower dome is penetrated by one 5-in. pipe, one 6-in. pipe and one 3-in. clean-out pipe. The 5-in. line connects the tank with the main which supplies the grounds, and also with the pump in the well. The 6-in. line connects the tank with the fire pump.

The reinforcement in the cylindrical wall consists of ½-in. square twisted steel bars. Below the lower reinforcing band both the vertical and the horizontal bars are spaced 12 ins. c. to c., with a few additional bars adjacent to openings. The arrangement of the reinforcement adjacent to the doorway is shown in Fig. 3. The horizontal reinforcing bars for the wall of the tank proper are spaced 3 ins. c. to c. for the first 5 ft. above the lower band, 4 ins. for the second 5 ft., 6 ins. for the third 5 ft., and 12 ins. c. to c. for the balance of the distance to the upper band. The vertical bars in the shell of the tank proper are spaced 12 ins. c. to c. The horizontal bars were placed, as nearly as possible, in the center of the wall, and the vertical bars were placed alternately upon the outside and inside of the horizontal steel.

The band which resists the thrust of the lower dome is reinforced with 12 bars of 1-in. square twisted steel, in addition to 4 bars of ½-in. square steel, as shown in Fig. 3. The upper band is reinforced in a similar manner, but it has only six of the 1-in. bars.

The domes are each reinforced with ½-in. square twisted bars placed as shown in Fig. 3. The additional bars adjacent to the vent openings are not required in the lower dome. The spacing of the bars in the lower dome is 8 ins. c. to c. and in the upper dome 12 ins. The bars in each direction are placed alternately near the extrados and near the intrados of each dome. A view of the reinforcement in the lower dome is shown in Fig. 4.

The minimum length of lap allowed for reinforcing bars throughout the structure was 2 ft. for ½-in. bars and 4 ft. for 1-in. bars.

The forms, which are used for the exterior of the cylindrical shell, consisted of 2 × 4-in. upright studs, to the inner side of which were tacked ½ × 3-in. redwood battens, bent to form the required circle. The forms for the inside of the lower half of the shell were made in a similar manner, but the forms for the inside of the tank proper were made in sections, to permit the large amount of steel to be more easily put in place. Each section covered an area of wall surface 18 ins. in height by approximately 5 ft. of circumference. One set of these sections formed the entire circumference, so that when bolted in place a height of 18 ins. of wall could be cast. A similar set of sections was then bolted on top of the first set for the next 18 ins. in height. Three such sets were used, two of which could remain in place while the third set was being removed and set in place at the top.

The forms for the domes consisted of radial ribs cut from 1 × 12-in. boards, over which ½ × 3-in. redwood sheathing was placed. In laying the sheathing a portion of the surface was covered with strips lying in a given direction, and then a different direction was used for another portion. After covering the ribs with the sheathing, the surface was covered with one layer of building paper, before placing the reinforcement.

The proportions of the ingredients for all of the concrete used was determined with reference to the voids in the aggregate. The clause of the specifications relating to this is as follows:

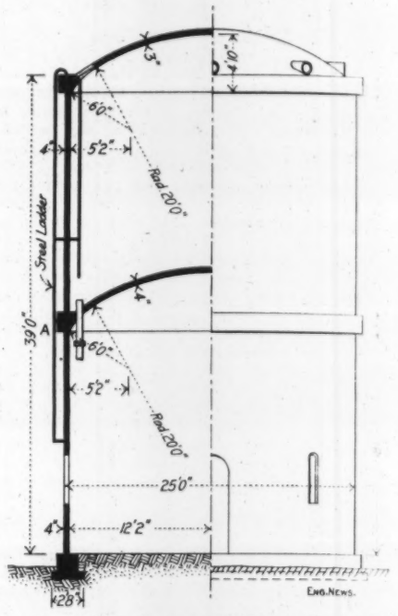


Fig. 2. Half-Section and Half-Elevation of Tank.

> The sand and stone to be used in the work will be tested for voids by the Inspector for the University, and the proper proportion of sand to stone will be determined from these tests. With the ratio of sand to stone as thus determined the proportion of cement to aggregate shall be one volume of cement to six volumes of aggregate for all concrete above the foundation and one volume of cement to nine volumes of aggregate for the concrete to be used in the foundation.

The object of stating the specification in this manner was to enable the contractors to make a definite estimate of the amount of cement to be used, since cement costs about twice as much in Arizona as it does in the eastern and middle states. The difference possible in the quantities of sand and stone does not make a very large difference in the cost.

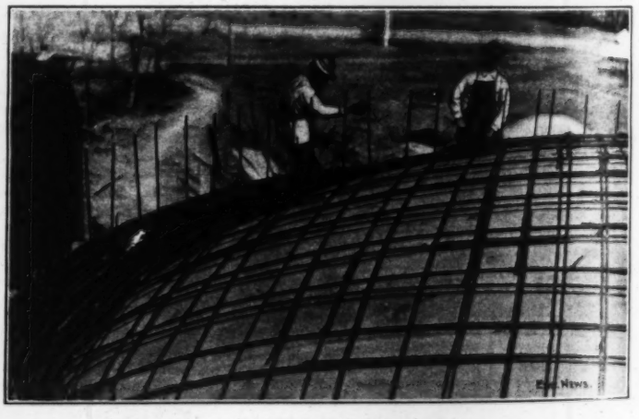


FIG. 4. VIEW OF DOME REINFORCEMENT.

The specifications called for two brush coats of neat cement to be applied to the interior of the tank. These were used and in addition a third coat was added after the tank had been filled and emptied for the first time. The third coat was added principally on account of two places at which the sweating appeared to be excessive, due probably to the presence of somewhat porous concrete. No other waterproofing

*Professor of Civil Engineering, University of Arizona, Tucson.

than the three brush coats has been used. When the tank was placed in regular service, which was about June 1, 1910, there was considerable sweating, but no more than was anticipated. By the middle of September the sweating had entirely ceased. There are some streaks of efflorescence on the outside of the tank but not such as to cause any considerable disfigurement.

The finish which was given to the exterior of the tank consisted of a brush coat containing a mixture of cement and white lime, the results of which were very pleasing. This coat was given before the sweating had ceased so that it would be a good plan to now give the upper half of the structure another coat.

The foundation for the tank was placed in September, 1909, but owing to delays in securing materials no further work was done until January, 1910. The work was then resumed, the concrete work being completed about the middle of March. The tank was not connected with the pump and water mains for some time after this so that the concrete had considerable time to harden before the tank was placed in service.

The structure was designed by the writer and was constructed by V. S. Griffith, contractor. The contract price was $2,551, which included all piping and connections required to connect the tank with the well pump, the fire pump and the water mains.

The Cape Cod Canal.*

By JACOB W. MILLER.†

During three centuries a canal has been advocated across the narrow sandy isthmus separating Barnstable from Buzzards Bay. As early as 1697, a committee was appointed to view the place, "it being thought by many persons very necessary for the preservation of men and estates" that the passage should be cut.

In 1776 Washington and the Revolutionary Council sent James Bowdoin and Machin there to see if a way by water could be found to avoid the enemy and the hazardous navigation around the Cape.

The Whitney company having decided not to continue the work, the charter fell into the hands of Messrs. Lockwood, Quincy A. Shaw and others who excavated over one million cubic yards near Sandwich, but were forced in the early part of 1890 to make an assignment to Col. Thomas L. Livermore.

The Lockwood charter of 1883 was supplemented by a new one on June 1, 1899, and this is that under which the present company is working, it having been kept alive through the energies of DeWitt C. Flanagan, who had certain amendments made in 1900, and from 1904 to 1909, together with Charles M. Thompson, of Sandwich, and others, endeavored to enlist financial interest in the undertaking.

The work is now being done by the Boston, Cape Cod & New York Canal Co., a corporation which is expending $12,000,000 under the Massachusetts charter of 1899.

From an engineering point of view, the problem is not great. The total length over the isthmus is 8 miles. The total length to 30-ft. depth in both bays is 13 miles. The soil to be cut is sand, and amounts to 17,000,000 cu. yds. The deepest cut is 29 ft. above tide-water. The channel at both ends of the route, the natural marshes and streams already furnish a waterway for boats of light draft. The difference in tide between the two bays necessitates no locks. The depth of the canal is to be 25 ft. Minimum width of bottom 100 ft. through the central portion of the canal; this will give a surface width at the narrowest point of 250 ft. The approaches will have a minimum bottom width of 250 ft. The right of way has been obtained, and in addition other tracts of land essential to the undertaking.

Agreements for the change of the railroad line have been made with the N. Y., N. H. & H. R. R. Co.; the railroad bridge necessitated thereby is completed; four dredges are deepening the five-mile western approach from Buzzards Bay; two large suction dredges are removing about 20,000 cu. yds. per day for the channel through the marshes at the eastern end of the canal.

A breakwater, 3,000 ft. in length, is being built to the northward of the channel, where it enters Barnstable Bay. Several other dredges are at work on the central portion of the line. Administration and other buildings have been bought and the necessary preparation made for a campaign of activity on the ground during the coming winter.

The bridges are being constructed on the basis of an ultimate depth of canal of 34 ft. They will each have an opening of 160-ft. span of the type known as the bascule lift bridge. The local travel across the canal will be accommodated by such bridges or ferries as experience may dictate.

The final estimates for the canal include the thorough electric lighting and other aids to navigation of the whole channel and approaches requisite for a region where fog prevails.

The tonnage through Vineyard Haven Sound to-day, which will be all tributary to the canal, amounts to 25,000,000, of which 9,000,000 tons is coal. The number of passengers between New York, southern and eastern points by water is to-day over 500,000 per year.

The freight tonnage is under the control of a small number of corporations, which tow the merchandise in barges containing from 1,000 to 3,500 tons. The towing companies now require a plant for a three-weeks round trip on account of the dangers and delays via the Vineyard Haven route. The cost of this plant will be reduced at least one-third, for the reason that not only is the distance shortened 66 mi., but the duration of the trip is greatly diminished. Insurance from perils of the sea will be lessened.

This new waterway is not in the strictest sense a canal, but a short passage connecting two portions of a much-traveled route through which a known traffic exists. Its conditions are analogous to those at Suez, where the profits have far exceeded the estimates.

Humanity demands the elimination of the dangerous, stormy and fog-bound route around the Cape. The loss of life and property in that locality has been appalling. The record, more or less incomplete, from 1843 to 1903, gives a minimum of 2,131 vessels wrecked in the Nantucket Shoals region, 908 of which were a total loss. Ten complete crews disappeared with their ships, and in addition, about 700 men lost their lives.

The completion of the canal will render unnecessary the proposed dredging of Pollock Rip channel at an estimated cost of some three million dollars, a sum which could be much more advantageously used by the Government in the neighborhood of the canal rather than being wasted in the tortuous and ever-shifting channels off Chatham.

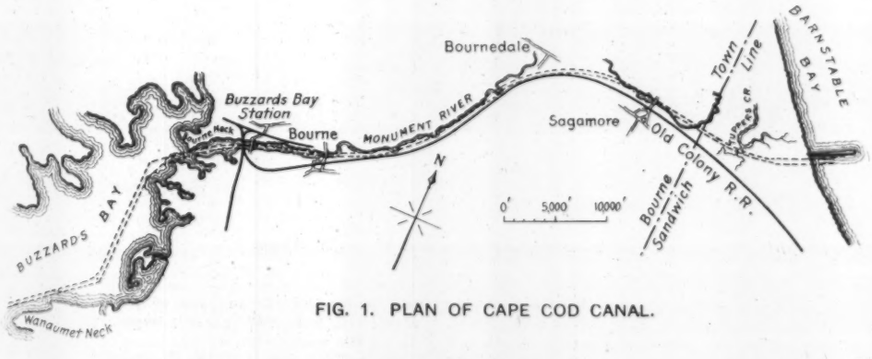


FIG. 1. PLAN OF CAPE COD CANAL.

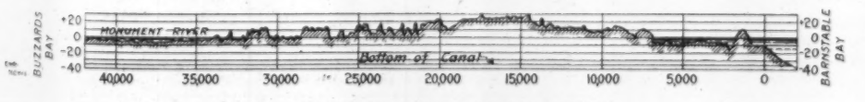


FIG. 2. PROFILE OF CAPE COD CANAL.

In 1780 General Knox made an estimate for a canal; then followed in 1791 the surveys of Winthrop and Hill, and in 1808 the report from Gallatin, Secretary of the Treasury. The names of Thorndike, Perkins and Loammi Baldwin are associated with the project in 1881. Subsequent government surveys were those of Major Perrault of the Army, and of Blake and Davis of the Navy.

From Colonel Foster's survey of 1870 there followed the charter to Russell Sturgis and C. H. Allen, and that of 1880 to the Cape Cod Canal Co., of which Mr. H. M. Whitney was President. The Government report of Colonel Warren made at this time contains the perfected survey upon which the present plans are based.

*Abstract from a paper "The History and Economic Value of Canals, with Special Reference to the Cape Cod Canal," read at the annual meeting of the Society of Naval Architects & Marine Engineers, New York City, Nov. 18, 1910.

†Vice-President, Cape Cod Construction Co., 23 Nassau St., New York City.

Condition of Structural Iron After Long Service.

For some years past certain government authorities in Germany have taken advantage of the occasions when an old iron bridge was being replaced by a new structure, by cutting samples from the metal of the old bridge and testing it to see whether the metal had lost strength by its continued service. Half-a-dozen or more such tests have been made, and uniformly the result has been very satisfying, giving practical certainty that a service of from twenty to fifty years wrought no injury to the metal.

The usual course of procedure was to cut two series of tensile-test samples out of floorbeams, one set out of the middle part of the flange and one set out of the end of the flange; the latter metal, having been subject to only negligible stresses, would probably represent the original character of the material fairly well, while the pieces from mid-length of the flange would contain the effect of frequent repetitions of a moderate working stress. In testing these samples, the usual quantities were measured: elastic limit, ultimate strength, ultimate elongation and reduction of area at fractured section. In every case the results of the two sets of samples (end and middle) were as close as the unavoidable variations in material and in test-manipulation permit. Some tests, indeed, showed better results (higher strength and greater elongation) for the much-stressed (middle) samples than for the end samples, though not sufficiently better to be outside the range of unavoidable variation. Moreover, the results were normal for new iron, thus eliminating the possibility that both sets of samples might have undergone serious but equal change.

Some further tests were made during the past year, and the results were of the same character. A terse statement on the subject is made in the annual report of the Prussian Royal Testing Laboratory (Gross-Lichterfelde West, near Berlin) for the year ending March 31, 1910, just issued, by the Director, Prof. A. Martens. We quote the passage as follows, with our own italics:

> Tensile tests of test bars taken from midspan and ends of chords and floorbeams of old wrought-iron bridges (which had been renewed), *showed almost exactly equal ultimate strengths and elongations* for the corresponding pieces which had been under different stress. Comparative tests on annealed test-bars showed only slight decrease in strength. The results warrant the conclusion that *the mechanical qualities of the iron were not injuriously affected by the service of approximately fifty years.*

In this case it is not stated whether the test-pieces were from railway or from highway bridges, though the former seems probable. Previously reported tests included railway bridges, at any rate. We thus have quite definite reasons for abandoning doubts which may have existed, on the question whether structural iron is slowly weakened by the innumerable repetitions of stress during service. Further, while the tests were all made on iron bridge material, our present knowledge of the relative behavior of iron and steel gives every reason to believe that the statement holds equally for bridge steel.

Concrete and Timber Snowsheds on the Great Northern Ry.

The severe snowslides on the Cascade Division of the Great Northern Ry. during last winter have led the railway company to make extensive improvements for the protection of its line, and most of these works will be completed before the coming winter. It will be recalled that one of the most disastrous slides on record occurred in April at Wellington, Wash., near the mouth of the Cascade Tunnel. Trains stalled by the snow blockades were carried down the mountain, and over 80 lives were lost.

The new protective work consists largely in the construction of additional snowsheds, one of which is notable for being built of reinforced concrete. The object of these structures is not so much to prevent blocking of the line by falling snow as it is to carry across the line the snow slides which come down the steep mountain slopes. These are great and irresistible masses of snow, trees and rock, but they can be readily guided across the tracks by protective roofs. For this reason, the roof of the shed must connect with and form a continuation of the mountain slope. In order to effect this at the locations for some of the new sheds, the line has been relocated so as to throw it closer to the mountain side. For particulars of this work and for drawings of the snowsheds we are indebted to Mr. A. H. Hogeland, M. Am. Soc. C. E., Chief Engineer of the Great Northern Ry.

Before the present improvements had been made there were 17 separate snowsheds on the line in the Cascades, having a total length of 7,593 ft. These sheds were located from a point 2½ miles east of the Cascade Tunnel to a point 8½ miles west of the tunnel. They had been built from time to time since the road was constructed in 1893 at points where experience showed they were required. They were all found to be effective during the very severe slides which occurred last winter.

After the experience of last season, however, it was decided to build additional timber snowsheds aggregating 5,411 ft., their design being according to the previous plans. These are located at 26 points and extend from 29 miles east of the Cascade tunnel to 9½ miles west of the tunnel. In addition to these, it was decided to build at Wellington a double-track snowshed, 3,900 ft. long, and on account of the great fire risk of timber sheds and the desire to have a permanent structure at this point, it was decided to build it of reinforced concrete. In order to place this shed so that the roof would form a continuation of the mountain side and thus carry the slides over the tracks, it was necessary to throw the line from 50 to 80 ft. further north into the mountain side for a distance of about a mile, involving heavy rock work.

At Berne, 4½ miles east of the Cascade tunnel, where the slides were very severe last winter, it was found practicable to make a change of line for a distance of 2.07 miles, placing the roadbed on the opposite (or north) side of Nason Creek valley. On this side the slope of the mountain is much flatter and is free from slides.

At several points where the timber sheds are being built, small changes of line are being made, both to improve the alinement and to place the roadbed largely in excavation, thus facilitating the construction of the sheds. Fire protection is provided for the timber sheds by making use of small streams coming down the mountain side adjacent to the sheds; these will serve to fill water barrels and supply a system of 6-in. piping equipped with hydrants and hose. Some of the sheds will have coal bins with an emergency supply for locomotives and the rotary snow plows.

At both Cascade Tunnel station and Wellington, changes in location of some of the former buildings are being made to put them in safer places, and a number of new buildings are being erected to take care of trainmen, laborers and equipment engaged in handling snow and to house and care for electrical equipment used in operating trains through the tunnel.

The general design of the timber snowsheds is shown in Fig. 1, and needs little explanation. The drawing represents the construction for double track. For single track the first span (16 ft. 4 ins.) is omitted and the wider span (18 ft. 8 ins.) takes its place. The cribbing on the up-hill side is anchored to the rock by laying the sills in trenches, as shown. Most of the timbers are 12 × 12 ins., and the roof is of a layer of such timbers placed close together and drift-bolted to caps or purlins on the posts. The slope of the roof is about 1 in 5. The design as shown was adopted in July, 1910, and is similar to the standard single-track design adopted in 1907, except in regard to the spans, as noted above. Both single track and double track sheds are being built on the present work.

The design is based upon several years' experience, as it is practically identical with that of the snowsheds built immediately after the construction of the line through the Cascades in 1893 and for several years afterwards. Practically the only differences from the older design in the 1907 and 1910 designs are (1) the substitution of square timber for round timber in the cribs, and (2) the use of posts and braces above the cribs, instead of carrying the cribbing up to the roof.

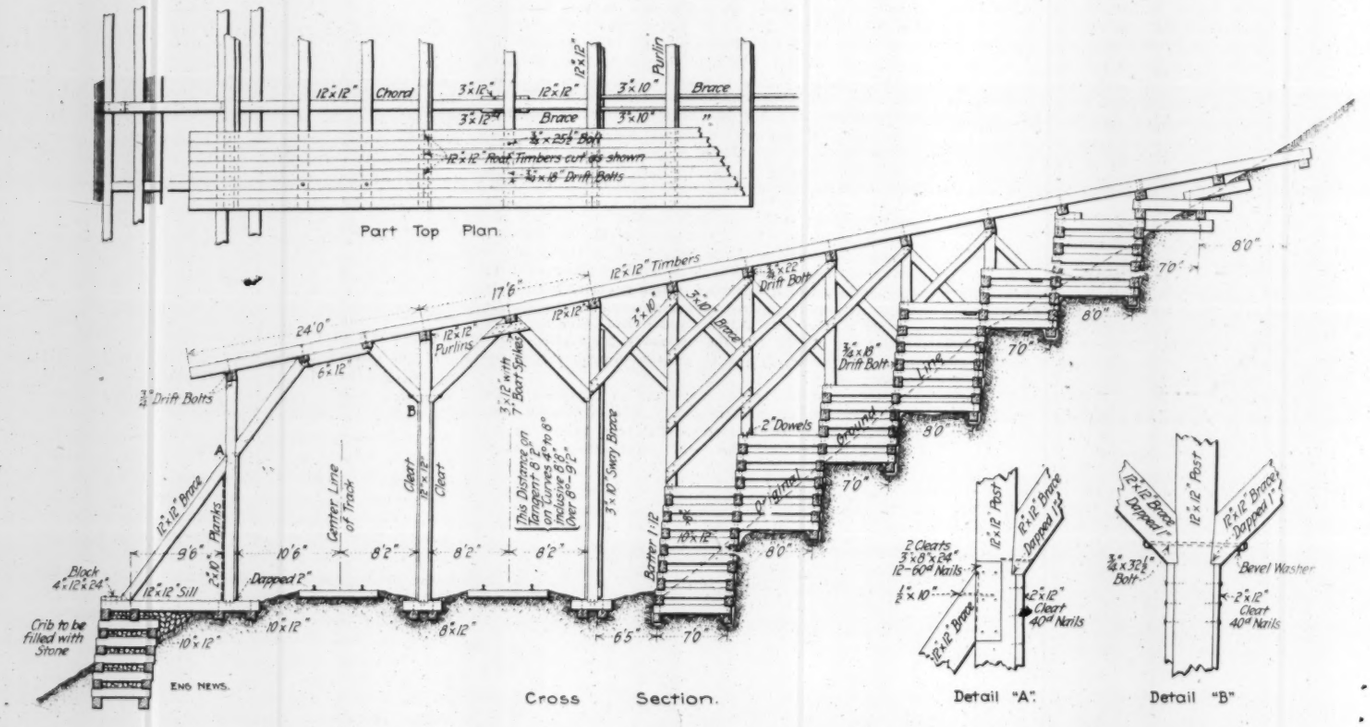


FIG. 1. STANDARD DESIGN OF DOUBLE-TRACK TIMBER SNOWSHED; GREAT NORTHERN RY.

Special interest attaches to the design of the reinforced-concrete snowshed, shown in Fig. 2, and we believe the shed at Wellington is the first ever built of this material. The 10-in. roof slab is supported by girders 24 ins. wide and 39 ins. deep (including the slab), which are spaced 10 ft. c. to c. and carried on posts 20 × 24 ins. The back wall is 17 to 9 ins. in thickness, with piers on the inner side coinciding with the roof girders; it is braced at the back by an anchor slab with 12-in. triangular buttresses 10 ft. apart. Expansion joints in the roof and back wall are provided at intervals of 80 ft. The roof slab is figured for 1,100 lbs. per sq. ft. and the beams are figured for 700 lbs. per sq. ft. of roof surface. The compression of the concrete is taken as 500 lbs. per sq. in., and the tension of the bars at 12,000 lbs. per sq. in. The structure contains about 8 cu. yds. of concrete and 1,500 lbs. of steel per running foot.

The construction shown in Fig. 2 is adopted where the back wall cannot be anchored to the mountain side. Fig. 3 shows the arrangement when the shed is built along the face of a rock cut, where such anchorage is practicable.

It is expected to have all of the improvements above mentioned completed this season, except

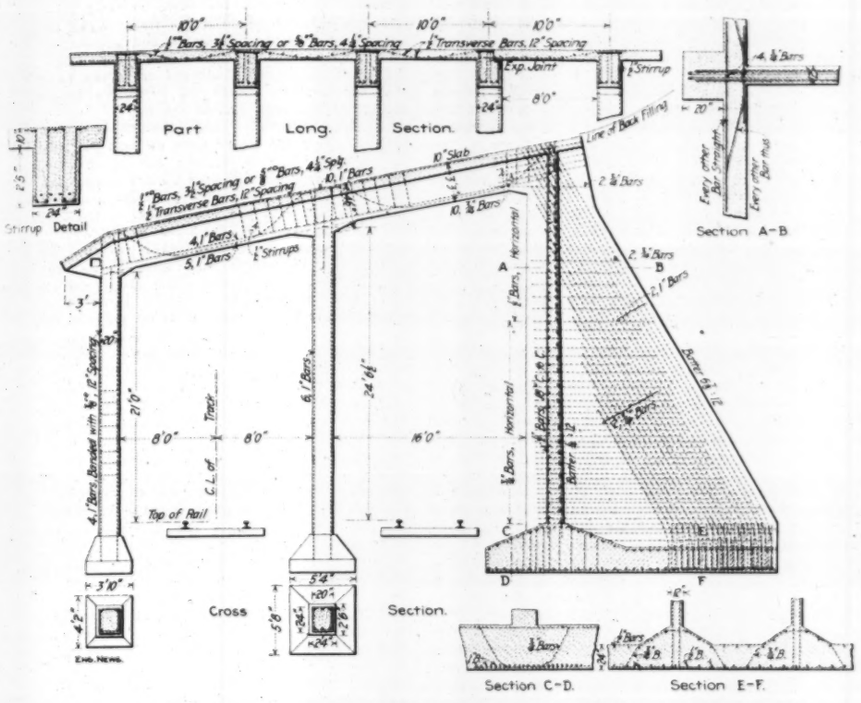


FIG. 2. REINFORCED-CONCRETE SNOWSHED AT WELLINGTON, WASH.; GREAT NORTHERN RY.

possibly a portion of the change of line at Berne. The approximate cost of these improvements is as follows:

Changes of line	$660,000
New timber snowsheds	370,000
New concrete snowsheds	465,000
New buildings and changes in present buildings	85,000
	$1,580,000

Big Guns and Secondary Batteries for Battleships.*

By SIR WILLIAM H. WHITE,† Hon. M. Soc. N. A. and M. E.

What description of armament is likely to prove most effective for speedily putting out of action modern battleships, having regard to existing materials of construction, structural arrangements, armor defense, means of propulsion and maneuvering, as well as to the characteristic qualities of guns, projectiles, explosives, torpedoes and mines now available for use?

It is generally agreed that future naval actions will probably be fought at longer ranges than have been adopted in the past. The main reasons for this increase in fighting range are to be found, on one side, in the development of locomotive torpedoes and the increase of their speed, accuracy and effective range; while on the other side stand no less important improvements in naval gunnery—including guns, propellants, projectiles, explosives, range-finders, sights and means of control. Nor can there be any dispute as to the fact that increase in gun-caliber in association with a constant muzzle velocity secures greater flatness of trajectory, and greater accuracy of fire, as well as superior maintenance of energy at long ranges. But when general statements of this nature are closely examined differences of opinion on practical matters are found to exist among men equally entitled to a respectful hearing, and these differences sensibly influence their choice of armaments.

Long Fighting Range and Secondary Armaments.

In regard to the probable fighting range for future naval actions there are marked differences of opinion. While all agree that it is likely to be greater than heretofore, two distinct schools of thought exist as to the minimum range likely to occur in practise. One of these asserts that an extremely long range will be chosen and maintained by commanders whose fleets possess greater speed and whose ships are armed on the "single-caliber, big-gun" principle; and it is argued that at this great range vessels so armed will be able speedily to put out of action an enemy's ships which individually carry fewer big guns, although these may also possess powerful and well-protected secondary armaments. These secondary armaments, it is urged, would be of no practical service at very long range, because of an alleged inferior accuracy (due to more curved trajectories traversed by their relatively small and light projectiles), their proportionately greater loss of energy as ranges increase, and their presumed ineffectiveness because of their lack of power to penetrate armor of moderate thickness, their alleged less proportion of hits to rounds fired, and the small bursting charges carried by their shells.

The other school maintains that, although actions may be begun at very long ranges on occasions when atmospheric conditions are favorable, average conditions of weather at sea will not favor that kind of attack nor make its results decisive. They give reasons for the belief that when an issue is joined, with the full intention to reach a decisive finish, it is practically certain that closer ranges will be reached; and they insist that the choice of armaments ought not to be governed by a set of assumptions which relate exclusively to extreme ranges and are subject to the continued efficiency of comparatively delicate sights and range-finders as well as apparatus for controlling gun-fire. In their judgment it is desirable to associate with big guns a powerful secondary armament of quick-firing guns, adequately protected and so placed as to be efficient both in horizontal command and in height above water, while free from interference arising from independent firing of heavy guns.

In support of this advocacy of good secondary armaments it is stated that modern types of battleships, including those on which armor defense has been most developed, still contain many vulnerable points, injury to which will seriously interfere with the fighting, maneuvering and steaming capability, the transmission of orders from conning-towers and control stations, signalling and other operations which considerably influence fighting efficiency. It is noted that more than one-half of the length of heavy guns is permanently exposed and unprotected. Cases have occurred in action where these unprotected portions have been injured, the heavy guns having been put out of action by the fire of light guns which were impotent at the fighting range against armor of moderate thickness. It is also maintained that the small height above water to which the hull armor rises, and the large unarmored areas of the sides above water, must involve serious risks to a considerable number of recent battleships should they be subjected to attack by a large number of 6-in. quick-firing guns using high-explosive bursters and common shell. The "volume of fire" obtainable from such quick-firing guns would, it is considered, inflict great damage to the thin shell-plating above the armor, and so permit considerable quantities of water to find access to the interior of the ship above the protective deck, although the hull armor was left intact. Such an entry of water might seriously prejudice stability or produce objectionable "list" and change of trim, even if it did not pass below the protective deck; but there would also be the danger of large quantities of water finding its way into hold spaces and there accumulating.

These anticipations of trouble, of consequent reduction of stability, loss of maneuvering power, diminished speed and lessened mobility, are treated by the other side as unlikely of fulfilment. In support of this view it is urged that, although at short or moderate ranges the 6-in. gun makes good practice and scores a high percentage of hits to rounds fired in comparison with the percentage attained by larger guns, yet at long ranges the percentage of hits to rounds becomes comparatively small. Consequently it is considered that injuries of the kind assumed to be produced by the fire of secondary armaments are not likely to be either serious or extensive.

GOOD SECONDARY BATTERY IMPORTANT.—There

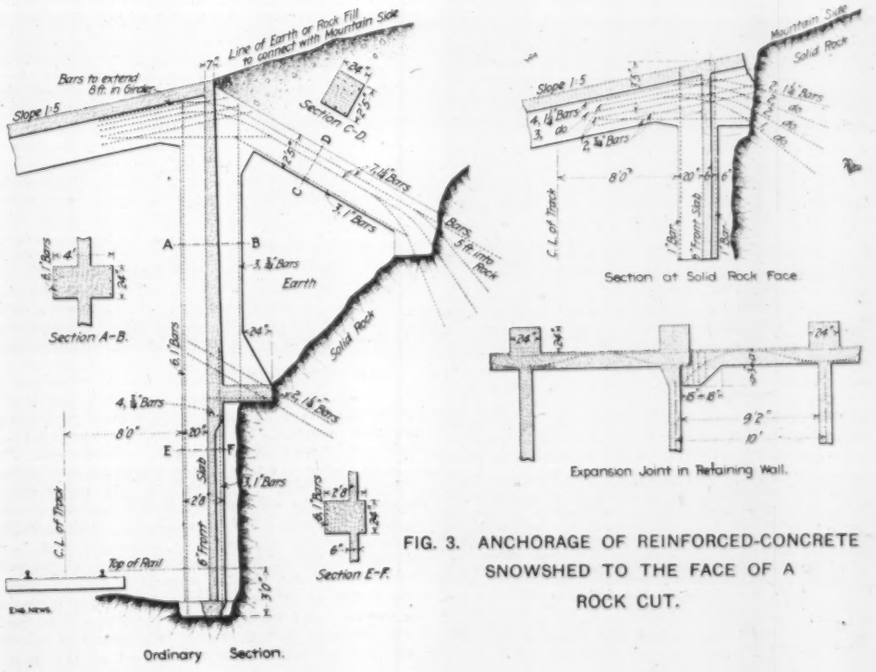


FIG. 3. ANCHORAGE OF REINFORCED-CONCRETE SNOWSHED TO THE FACE OF A ROCK CUT.

*Slightly condensed from a paper entitled "Notes on the Armaments of Battleships," presented at the annual meeting of the Society of Naval Architects and Marine Engineers, New York, Nov. 17, 1910.

†Late Chief Constructor, British Navy, Cedarcroft, Putney Heath, London S. W., England.

is obviously room for difference of opinion in regard to such matters and the proper method is to trust to experience when attempting to reach a decision. When tested on a proof ground, with guns and targets fixed and ranges known, the percentage of hits to rounds fired will undoubtedly become greater at long range as the caliber of guns is increased. These conditions, of course, do not represent those which would occur in a sea fight, between fleets or between single ships, moving rapidly in relation to one another, and commonly in circumstances which will be accompanied by rolling or pitching of the gun platforms. It is not possible in peace time to imitate all the conditions of war; in particular the disturbing influences which necessarily arise when a warship is fired at by an enemy while making an attack cannot be represented. But there is in existence a considerable body of information based upon "battle-practice" at long ranges. These facts have not been published in detail nor are they likely to be. The writer has, however, been assured by naval officers of great experience possessing full and accurate information of this kind, who have carefully analyzed results of firing at very long ranges, that the percentage of hits to rounds fired obtained with 6-in. guns under service conditions at sea compares favorably with and is not inferior to the percentages obtained with guns of larger caliber. Furthermore he has good reason for the belief that actual trials do not confirm the objection raised to "mixed" armaments on the ground that the simultaneous discharge of guns of different calibers must be accompanied by diminished efficiency in the control of fire and in the proportion of hits to rounds made by guns of different calibers. If these conclusions be true—and the writer is convinced that they are so—then it is unquestionable that even at long ranges the secondary armaments of battleships will be capable of delivering a "hail of fire" against an enemy, and of exercising an important influence on the result of an action.

Published accounts of naval engagements during the Russo-Japanese war also emphasize the importance attaching to attacks made by efficient and well-handled secondary armaments carried by Japanese ships. It is probable that the deep-laden condition of Russian ships at Toushima tended to increase sensibly the prejudicial effects of fire from the lighter guns of the Japanese fleet; but after making full allowance for this feature it appears proven that considerable danger must always attend the extensive damage to unarmored superstructures which quick-firing guns of moderate caliber can inflict even at long range. What the "volume of fire" from such guns involves in damage done to signalling apparatus, control appliances and the general working of a ship in action, Captain Semenoff has graphically described. What it may do in making ships unmanageable or in temporarily destroying the command of maneuvering capability was demonstrated at Toushima and in the battle of Aug. 10, 1904, off Port Arthur. Under the terrible hail of projectiles and of fragments of shells containing high explosives it has happened and will happen again, that a "joint in the harness" is discovered and the ancient story of the "bow drawn at a venture" is repeated. The Japanese authorities, who may be supposed to have all the facts of the war in their possession, and who are certainly capable of analyzing them, and drawing therefrom lessons for guidance in future practice, have never departed from the use of powerful secondary armaments. Personal conferences with leading Japanese authorities on naval matters enable me to say that they attach the utmost importance to the association of such armaments with guns of large caliber. In fact the trend of naval opinion throughout the world during recent years has been against the perpetuation of the system which discarded all guns except those of large caliber and 3-in. guns for use against the attacks of torpedo vessels.

FEWER SMALL CALIBERS.—As to the most suitable numbers and calibers of guns making up the secondary armaments of modern battleships little need be added. There are obvious objections to the employment of many calibers, each requiring special ammunition and making separate control desirable. In some ships guns of 6-in., 4.7-in., 3-in. and smaller calibers have been mounted. Such a multiplication of calibers appears both unnecessary and objectionable. Probably the explanation is to be found in an intention to use guns from 4.7-in. downwards as an active defense against the attacks of torpedo vessels, and to supply 6-in. guns as auxiliaries to the 12-in. guns in action. The writer has long advocated a simpler arrangement which, in his judgment, would fulfill all requirements, and ventures to quote remarks on this head made at the Institution of Naval Architects a few months ago:

> The ideal armament, to my mind, is that which embodies a certain and not an extravagant number of heavy guns associated with a considerable battery of 6-in. guns. It does not seem to me a difficult matter to supply these 6-in. guns with ammunition which shall be efficient when used against attacking torpedo vessels. If anything in addition to such a secondary armament of 6-in. guns is wanted I should say "man-killing" guns capable of very rapid fire might be used for sweeping the decks of torpedo vessels; they could be placed and fought in almost any position and would require only shield protection.

Twenty-six years ago the writer, in conjunction with the late Lord Armstrong, worked out a design for a vessel in which ammunition of the special kind mentioned was provided for guns of 5-in. to 6-in. caliber for use against torpedo craft. It has been reported recently that experiments have been made with shrapnel fired from 12-in. guns as a possible means of repelling torpedo attacks. If this be true the principle advocated has been carried to an extreme which will not commend itself generally, but the experiments constitute a virtual confession that 3-in. guns are not sufficiently powerful to deal effectively with modern torpedo vessels. That view of the matter has been confirmed by the adoption of 4-in. and 4.7-in. guns instead of 3-in. in ships of recent design; while 6-in. guns are now recommended for defense against torpedo vessels in quarters where 3-in. guns were advocated four or five years ago as the only auxiliary armament required. The compass has been "boxed" in a very short time, and without any war experience to justify the change of opinion.

The main reason for preferring a caliber of about 6 ins. is that experience proves projectiles of about 100 lbs. weight to be the maximum which can be "man-handled" continuously and rapidly, while accuracy of fire even at long range can be combined with rapidity of discharge and remarkable effectiveness against the lightly armored, unarmored and vulnerable points of war-ships. Personally, I have always maintained the view that these quick-firing guns, their crews and the supplies of ammunition should have a remarkable amount of armor protection against the fire of similar guns carried by an enemy. In designs for which I was responsible more than 20 years ago, in which the earliest 6-in. quick-firing guns were mounted, such protection was provided. Nothing that has since occurred has shaken that conviction, and my opinion remains fixed that the secondary armament should be not merely available for use in repelling torpedo attacks but should be used in battle and be regarded as a valuable auxiliary to the heavy guns. The disposition of the 6-in. guns should be of a character that will effectively fulfill both these functions. It is not difficult to secure that result in designing war-ships, and to place the 6-in. guns so that they shall not be hampered or interfered with by the fire of the heavy guns, provided that the number of the heavy guns carried in a ship is not made excessive.

The Number of Heavy Guns.

Turning to the consideration of what constitutes a reasonable number of heavy guns for the principal armament of a modern battleship, it will suffice on this occasion to re-state the writer's conclusions and to briefly summarize the reasons therefor. These conclusions are admittedly open to debate and other views may be maintained on the basis of solid argument. The case is necessarily one for compromise, and therefore for difference of opinion as to the best course to be pursued.

THE "MICHIGAN" ARRANGEMENT.—There are two positions for heavy guns which by common consent confer supreme advantages, and are always utilized. These positions are at the center line of the deck; one commanding right-ahead fire, with large arcs of horizontal training reaching well abaft the beam on each side; the other possessing corresponding command right astern and over large arcs of training reaching well before the beam. Until the "Michigan" and "South Carolina" were designed it was the general practice to mount one or two heavy guns—two in nearly all cases—in each of these positions. Superposed turrets were tried in some cases, and 8-in. guns were mounted in the upper emplacement; but this practice did not find much favor and may be considered to have dropped out of use. It was a new and bold departure in the "Michigan" and "South Carolina" to place two turrets in each of the supreme positions, and to arrange for firing the guns in one turret over the top of the other turret. That arrangement proved successful, however, and has been largely adopted in recent ships of all navies. When associated with the mounting of guns in pairs this system permits the effective use of eight heavy guns; if three guns are mounted in each turret then twelve heavy guns can be given equal arcs of command, and all the guns can be used on each broadside.

TWIN OR TRIPLE MOUNTING.—The writer has always favored and still favors the system of mounting heavy guns in pairs. French designers long preferred separate mountings for single heavy guns, and placed two gun stations amidships—one on each side. The French system was tried in the British armored cruisers "Imperieuse" and "Warspite," and as the result of trials it was not repeated; the French themselves subsequently abandoned the arrangement. Twin-mountings were universally employed for a long period, and, in the writer's judgment, that plan embodies a reasonable compromise. Considerable economy is thus affected in the weight of the mountings and armor protection for a pair of heavy guns as compared with what is needed with separate mountings for each gun; and although the risk of simultaneous disablement of two guns is necessarily incurred when they are carried on [illegible] turntable and within the same armored station, that does not seem to be an undue risk. When three guns are mounted on one turntable and exposed to similar risks of simultaneous disablement then, in the writer's judgment, too many "hostages are given to fortune," and economy in weight of protective material and mountings has been carried too far.

"DREADNOUGHT" ARRANGEMENTS.—For more than 20 years the heavy guns of most battleships continued to be four in number, and in nearly all cases they were mounted in pairs on the center line of the deck at the two important positions above described. In connection with the introduction of the latest types of battleships—usually described as "Dreadnoughts"—a necessity arose for finding other positions for heavy guns. Ten or twelve such guns have been usually thought desirable; thirteen guns are to be carried in ships now building. Consequently three or four additional gun stations have had to be provided, and large hold spaces have been devoted to the stowage and supply of ammunition immediately below each turret. Different dispositions of heavy-gun stations have found favor, not merely in different navies, but in successive ships of the same navy. In these circumstances it becomes obvious that no fixed principles have been established or generally followed hitherto in disposing heavy-gun armaments. It is unnecessary to describe in detail various arrangements adopted in recent ships, because they are well known to members of this Society; but mention may be made of certain salient features which illustrate the diversity of views that have prevailed.

In many cases history has been repeating itself; arguments which were familiar thirty or forty years ago have reappeared and have been treated as novelties. Widely differing estimates have been formed in regard to the relative importance attaching to "end-on" and broadside fire. In the earlier French disposition—in which two heavy guns were mounted forward and aft on the center line of the deck as bow and stern chasers, and two others in positions on each broadside (nearly amidships) which enabled them to be fired directly ahead or astern—"end-on" fire was treated as of equal importance with broadside fire. Three guns were available on each broadside and three guns could be fired either ahead or astern. In ships of the "central-citadel" type (designed about 1873-78) four heavy guns were carried in two turrets which were placed *en echelon* nearly amidships, and it was possible to fire all four guns parallel to the keel, either ahead or astern. Each pair of guns had 180° of training on the broadside whereon they were placed, but on the other broadside these guns had only a very limited arc of training. In these vessels, therefore, "end-on" fire was theoretically superior to broadside fire. Experience showed, however that superstructures erected above the upper decks—primarily to limit the effect of "blast," when the guns were fired parallel to the keel-line or at large arcs of training from the beam, imposed serious limitations and disadvantages against a moving target placed nearly ahead or astern. The echelon disposition was, therefore, abandoned and a return was made to the earlier plan which mounted four guns in two commanding positions forward and aft on the middle line of the deck.

During the last five years we have seen both the old French disposition and the echelon arrangement reproduced (in principle) in new designs, only to be abandoned in later designs, in some cases before practical experience had been gained with the arrangement which was abandoned. Now there is a marked disposition to place all the heavy-gun stations at the center line of the deck, so that all the guns may be available on both broadsides. This is a return to a disposition adopted in the earliest British turret ships built nearly half a century ago. The "Royal Sovereign" (1862) and the "Prince Albert" which followed immediately after her each had four turrets so placed. It may be noted that the United States Navy took the lead in this last movement, and further has the credit of demonstrating the possibility of associating powerful bow and stern fire with the maximum of broadside fire over large arcs of training, by placing some turrets higher than others and firing over the lower turrets on certain bearings.

END-ON AND BROADSIDE FIRE.—Advocates of end-on fire assert that an attacking ship which is end-on to an enemy presents to her fire a target of which the projected area (on a vertical plane) has, for its largest dimension, the extreme breadth of the ship and for its height the height of her uppermost deck, so that the chance of hitting effectively is diminished greatly as compared with broadside attack. This statement overlooks important conditions, and is therefore misleading. A ship attacking end-on must present to the fire of an enemy a horizontal target of which the greatest dimensions are the full length of the vessel and (transversely) her extreme breadth. Consequently errors in elevation of guns which the enemy may make are less likely to result in missing this long horizontal target than would be the case if corresponding errors were made when firing at a target of which the greatest dimension was the extreme breadth of a ship lying

broadside on to the line of fire. No one can deny that the minimum of defense of vital parts of battleships—especially against "dropping" fire at long ranges—is to be found in the resistance offered by protective-deck plating, and not in the strength of vertical side armor. Nor can it be doubted that even in single-ship actions it would hardly be possible for a combatant to maintain for long the assumed end-on position; while in fleet actions no commander could possibly effect a similar object with a large number of ships by any conceivable tactics, if engaged against a skilful and mobile enemy. If a choice has to be made, therefore, between highly developed broadside and end-on fire it seems reasonable to give precedence to the former. This has been done in the majority of recent battleships; but it is also reasonable—having regard to great and rapid variations unavoidably occurring in the relative bearings of ships in action—to develop end-on fire to a reasonable extent. The compromise represented in the "Michigan" class now secures wider acceptance and is likely to become more generally adopted.

OBJECTIONS TO LARGE NUMBERS OF HEAVY GUNS.—One is led to inquire, in present circumstances, whether it is possible to discover a reasonable basis for fixing the maximum number of heavy guns which should be carried by a battleship. It has been previously stated that the number of heavy guns actually carried in ships built since 1905 varies from eight to thirteen per ship, ten or twelve being carried by most ships, and the stations varying from four to six. Although it is not possible to lay down hard and fast rules, or to reach any general agreement, certain considerations may be mentioned, which must be kept in view by all designers of warships. For instance, whenever heavy guns are mounted in positions near the middle of the length of a ship it is unavoidable that spaces shall be found for the installation of the magazines, shell rooms, ammunition supplies and gun-working machinery in a region mainly appropriated to the propelling apparatus and stowage of fuel. This juxtaposition of features essential to the efficiency of the principal armament and of those upon which efficiency of propulsion depend, involves considerable difficulties upon which one need not dwell. Experience on a large scale proves the need for special precautions in order that magazines may be kept cool and deterioration of the ammunition prevented; in not a few instances these magazine spaces make difficult the communications between compartments of the hold occupied by the propelling apparatus, or interfere with the efficient control and working thereof; while the arrangements for transporting coal from the bunkers to the stokeholds are rendered inferior in efficiency to those which exist in ships wherein the spaces assigned to engines, boilers, bunkers, are not broken up by magazines and shell rooms. It is also admitted that in ships which have five or six heavy-gun stations, the deck arrangements, the stowage and handling of boats and other matters incidental to every-day work and general convenience are all less satisfactory and convenient than are the corresponding features in ships where no heavy guns are mounted in the central portions of the length. In the last-mentioned vessels less difficulty is experienced in dealing with magazine temperatures, or in arranging for powerful secondary armaments, which shall be thoroughly efficient and practically free from risk of interference being caused by the fire of the heavy guns.

The main reason advanced in favor of mounting ten to twelve guns in a battleship is that, in this manner, an overwhelming concentration of offensive power is secured. It has been the fashion in some quarters to adopt the simple method of assessing offensive power by counting the number of 12-in. guns carried. A ship carrying, say, twelve 12-in. guns has been reckoned equal to three ships each armed with four 12-in. guns even when the latter have carried in addition powerful and well-protected secondary armaments. It hardly seems necessary to deal with such a method of comparison in this paper.

Under-water attacks by torpedoes, by submarines and by mines are undoubtedly among the greatest dangers to which modern war-ships are exposed, although the gun still remains the supreme weapon of offense. It is agreed that a single successful blow struck by a modern torpedo will probably produce damage which will put even the largest ship "out of action" although she may not be sunk. On this ground, therefore, it may be maintained that a limit ought to be put upon the concentration of gun armaments upon single ships, and upon the increase in dimensions and costs of individual ships; because a single successful blow may, by general consent, bring about such a serious proportionate loss to a fleet by injury to one vessel and her compulsory withdrawal from action. Moreover, many services are required from a fleet in the performance of which capacity for distributing the force is no less important than the power of concentrating it for an attack. From this point of view unlimited increase in dimensions, cost and individual power of battleships is not desirable. As to the assertion that increased steadiness of ships, considered as gun platforms, necessarily proceeds *pari passu* with increased dimensions, it need only be said that experience has proved the doctrine to be fallacious. Battleships of the modern type carrying numerous heavy guns high above water, and protected by great weights of armor, must be endowed with considerable initial stability in order to possess sufficient range of stability. As a consequence they have proportionately shorter periods of oscillation, as well as lessened steadiness under unfavorable conditions of sea. It is a matter of common knowledge also that some of the steadiest war-ships ever built have been vessels which were of small dimensions when judged by present standards. This feature in behavior, of course, is distinct from the power of maintaining speed in a sea-way; that quality is undoubtedly favored by increase in length and weight.

No claim is made that new statements of the case have been embodied in the foregoing summary of points in favor of or adverse to the adoption of battleship armaments comprising a large number of heavy guns in each vessel. All that has been attempted is to bring such points into view, fairly and briefly. Having done so the writer desires to place on record his personal opinion that: *In no case is it desirable to carry more than eight heavy guns in a single ship; These guns are best arranged in four positions, as in the "Michigan" class; They should be supplemented by a powerful and well-protected secondary armament.*

Increase in Caliber of Naval Guns.

Allusion has been made to the movement now in progress for using guns of larger caliber in battleships and armored cruisers. In the United States the 14-in. gun has found favor; in Great Britain the 13.5-in. has been reintroduced; in Germany the 12-in. has been adopted instead of 11-in. The reasons given for this departure from long-established usage may be summarized as follows:

1. With larger calibers it becomes possible to reduce muzzle velocity and to diminish erosion in the interior of guns, and yet to secure ample penetrating power against armor and superior maintenance of energy at long ranges.

2. A flatter trajectory and increased accuracy at long ranges can be obtained with guns of larger caliber.

3. Increased capacity of bursting charges can also be secured for all descriptions of shells.

4. If it be assumed that a certain total striking energy and a certain total shell-burster effect are to be obtained by one discharge of all the heavy guns mounted in a ship, then it is possible to diminish the number of guns carried if the calibers are increased, and to obtain more efficient control of fire.

All these arguments in favor of larger guns are, in principle, identical with those employed more than thirty years ago when increase in the weights and calibers of naval guns was made with great rapidity. The arguments then prevailed for a time; and history is, in this particular, now repeating itself. At that period in the British Navy we passed from 12-in. breech-loading guns weighing 45 tons and firing projectiles of 714 lbs., to 13.5-in. guns weighing 67 tons and firing 1,250-lb. projectiles, ending with guns of 16.25 ins. caliber weighing 110 tons and firing 1,800-lb. projectiles. Within a few years experience then induced a return to 12-in. guns and for a long period no larger caliber was used, but great and continuous improvements were made in guns, projectiles and explosives. Behind the reversion to more moderate calibers stood the conviction, based on actual usage and experiment, that the 12-in. caliber was sufficiently large for all practical purposes, whether armor-perforation or shell-power was considered; and that, on the whole, for a given expenditure of weight on the principal gun armament of a battleship the 12-in. gun furnished the best combination of adequate numbers and individual power. It has been stated recently that the chief reasons for abandoning the larger calibers were to be found in the difficulty encountered in making such guns or in loading and working them. As one who was intimately concerned with the matter the writer denies that these were the real causes of return to the 12-in. caliber. The subject was fully discussed by the Admiralty in 1888, when the designs for battleships of the Royal Sovereign class were under consideration, and it was then decided to make the change as soon as possible; but no satisfactory design for 12-in. guns was then available and consequently the 13.5-in. caliber was used once more. At the same time action was taken to obtain a new and satisfactory design of 12-in. gun, and as soon as it was availble it was adopted in the Majestic class (1892).

Twelve-inch guns of the latest design are much more powerful weapons than their predecessors of twenty years ago; their projectiles are capable of penetrating at very long ranges the thickest hull armor fitted on the sides of existing battleships. As regards armor perforation it is generally admitted that no increase in caliber is required. Although their trajectories may not be so flat as those of larger guns practice made at sea with 12-in. guns at very long ranges is undoubtedly excellent. For the same approximate total weights of guns, ammunition, gun-mountings and mechanisms, and protecting armor it is possible to provide for five pairs of 12-in. guns as against four pairs of 13.5-in. guns. In other words if equal rapidity of fire is assumed to be obtained by guns of the two calibers, for each ten rounds delivered by the 12-in. guns only eight rounds would be delivered from the 13.5-in. It is improbable that in actual service equal rapidity of fire would be long maintained by the larger guns; but in any case the unavoidable uncertainties attaching to naval gunnery make the larger number of rounds fired and of hits made by the 12-in. guns a most important feature in the comparison of their efficiency with that of larger guns.

For attack on the armored portions of modern battleships (as already remarked) blows from the 12-in. guns are admittedly heavy enough so that they would have a distinct advantage in this respect. In regard to shell fire, trials made against the French battleship "Jena" and against several British ironclads demonstrate conclusively that shell fire from 12-in. guns can rapidly destroy unarmored portions of battleships and can inflict great damage on the armored portions and on protective decks, provided projectiles of suitable design are used. The larger bursters possible with 13.5-in. shell—say about 40% greater in weight than the bursters of 12-in. shells—will undoubtedly inflict greater damage for each successful hit; but the number of such hits will be smaller unless the weight assigned to the principal armament and its protection is increased so as to have an equal number of the larger caliber guns; and that means the construction of larger and more costly ships. Fancy pictures have been drawn of wholesale damage which can be done by the explosion on board a war-ship of one common shell from a 13.5-in. gun, and of its far-reaching and destructive effects as compared with those of a single shell from the 12-in. gun. The writer has witnessed many experiments with high explosives, and knows that enormous local injuries may be inflicted by a single shell explosion. Yet he ventures to doubt the accuracy of much that has been written both as to the vastly greater relative power of 13.5-in. shells and as to the absolute necessity for adopting guns of that caliber in order to secure effective shell fire.

Without assuming the role of a prophet he is of opinion that just as history is now repeating itself in regard to the adoption of larger calibers, so in the course of a few years it is likely to repeat itself by a return to more moderate calibers as experience is gained and extended firing trials are made with the larger guns now being introduced. All the reasons given above for preferring the 13.5-in. caliber to the 12-in. would apply also to an argument in favor of still larger guns; and it may happen that, before the tide turns, larger calibers than 14-in. will be again mounted just as was done thirty years ago. But the turn will doubtless come in due course and for the same reasons as before.

A SCRAPER-BUCKET EXCAVATOR in use on part of the New York State Barge Canal, is stated to have averaged over 2,000 cu. yds. per 24 hours since it was put in service on Oct. 16. It is worked in three shifts of eight hours, but the excavation is done mainly on the two shifts from 5 a. m. to 9 p. m. During the third shift, repairs are made, parts overhauled, tubes cleaned, and fires are cleaned at each end of the shift. This is done in order to keep the machine in condition for steady work. If any time remains on this shift, it is employed in excavating. The record would have been higher, it is expected, but for a bed of loose gravel in which the bottom of the excavation was made. As there was a 3-ft. depth of water in the pit, the gravel would break away and give only half a load in the bucket. In clay, earth, or material that will give a full load it is considered that the machine could average 200 yds. per hour, and this was actually exceeded on one shift when the conditions were favorable. The crew comprises an engineman and a fireman, with several men to adjust the track sections, which are swung from the rear to the front of the machine by the boom.

The machine is a revolving derrick car, mounted on four four-wheel trucks running on two parallel tracks of 3-ft. gage. It has a 100-ft. boom, handling a bucket of 62 cu. ft. capacity, but in dry material the bucket will carry a load of 3 cu. yds. Coal is hoisted by a jib crane with compressed air motor. The water supply is pumped up through the center casting into an open heater, from which it goes to a tank and is heated to nearly boiling point by exhaust steam from the pumps and the swinging engine. It is fed to the boiler by a hot-water pump. A generator mounted on the same shaft as a rotary engine supplies current for a 4,000 c. p. electric headlight. The machine was built by the Lidgerwood Mfg. Co. and is operated by Fitzgerald & Caldwell (Palmyra, N. Y.) on contract No. 49 of the canal.

PANAMA CANAL EXCAVATION during November totaled 3,006,037 cu. yds. or a daily average of 125,251 cu. yds. for the 24 working days. With the exception of March, 1910 (3,067,479 cu. yds.), this is the first month since April, 1909, that the total monthly excavation has passed the three million mark, and the daily average is the highest since that month. The rainfall during November was 14.83 ins. Concrete to the amount of 163,271 cu. yds. was laid during the month and 452,173 cu. yds. of fill was placed in the dams.

Reinforced-Concrete Piers at the U. S. Naval Station, Olongapo, Philippine Islands.

By C. A. CARLSON.*

The U. S. Navy Department has recently completed the construction of two piers at the U. S. Naval Station, Olongapo, P. I., for berthing vessels of deep draft, that present certain new features in the adaptation of the principles of reinforced-concrete to structures of this character.

The station, comprising about 65 square miles of territory, is situated 50 miles north of the city of Manila, bordering on a well-protected natural harbor formed by the waters of Subig Bay.

*Civil Engineer, U. S. Navy, on duty at Bureau of Yards and Docks, U. S. Navy Dept., Washington, D. C.

A few years prior to the Spanish War, the site was selected by the Spanish Government for the establishment of its principal naval base in Philippine waters, and at the time of its capture by our navy most of the shop buildings and storehouses were in an advanced stage of construction. The damage inflicted by the gun fire from the naval vessels was afterward repaired, the buildings completed, and to-day they still form the main shops of the naval station.

Upon the arrival of the floating dry dock "Dewey" early in July, 1906, after an eventful voyage in tow from the United States, this station became the only naval station possessed by the U. S. Government in the Far East capable of providing docking and limited repair facilities for battleships and cruisers. The two piers recently completed were the first permanent structures built for berthing deep draft vessels alongside, in proximity to the dock yard.

The main shop district is located on a [illegible]ngue of land jutting out into the harbor [illegible]ning virtually a large natural pier with deep [illegible]ater close in to shore. Across the tip of the [illegible]gue known as "Rivera Point" the one pier situated, while the second pier lies about [illegible] ft. west of Rivera Point on the south shore [illegible]ctly opposite to where the floating dock "De[illegible]" is moored.

In general the piers were designed with reinforced-concrete cylinders set over native wood piles driven into place until the heads were approximately even with the bottom surface of the required depth. The concrete cylinder, with a flaring bell at the base to encompass a group of three piles, was formed by molding ashore a thin reinforced-concrete shell of suitable length for its location in the pier. This shell served as the form for each cylinder, thus obviating the use of steel shells or other form devices in the water. A steel framework connected the heads of the cylinders. Reinforced-concrete slab construction formed the deck. Concrete encased all steel beams and rods.

The pier at Rivera Point runs approximately parallel to the original shore line. The abutment consists of a gravity section concrete wall founded on piles, located approximately at the extreme low-water line, extending the length of the pier, 300 ft. The cylinders are arranged in three rows parallel to the abutment or retaining wall, making the pier deck about 60 ft. in width. Along the outer edge and the ends there are fastened waling timber. Native hardwood fender piles are secured to the outer waling, and at the corners are placed pile clusters or dolphins, standing entirely free of the structure. This pier provides a depth alongside of 30 ft. at mean low water.

The pier at the floating dock "Dewey" being on the main or outer harbor is more exposed, and during the typhoon season receives the ground swell from the ocean after heavy storms. Similar conditions with deep water running close up to the shore obtain at this location, as at the pier at Rivera Point. From the pier to the nearest point on the "Dewey," a distance of less than 200 ft., the water increases to a depth of nearly 60 ft. at mean low water.

The pier lies with its outer row of cylinders parallel to and about on the contour line for 25 ft. depth of water. The inshore side is in shallow water sufficient for berthing lighters and steam launches. At the east end a short approach connects to the shore abutment. The pier is 332 ft. long by 45 ft. wide and is provided with a railroad track of Philippine standard gage (3 ft. 6 ins.) to connect with the yard system.

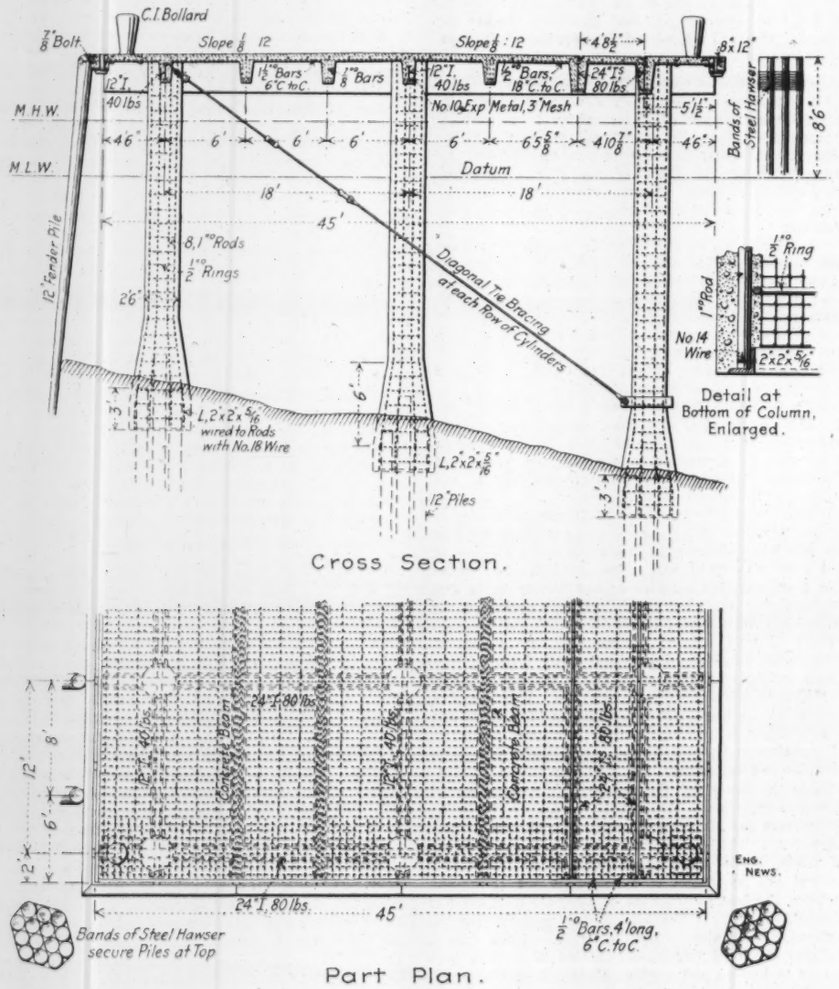
This pier standing free and nearly parallel to the shore line, derives no appreciable support from the short abutment at the east end and is dependent upon diagonal sway bracing rods in the transverse bents in addition to the resisting moment due to the fixity of the cylinder heads to the floor system.

Two pontoons each of 24 ft. beam and 123 ft. length constructed of wood complete the pier equipment for affording access to and from the floating dock.

General Description.

The design of the piers follows the well known open type of cylinder or caisson construction (Fig. 1), but instead of using cylinders of steel plate or cast iron, the hollow cylinders are made entirely of reinforced concrete, cast and molded their full length in one operation. They are 30 ins. in diameter through the shaft or column terminating at the base in a flaring bell to permit setting over a group of three wooden piles.

The reinforced-concrete cylinders were molded ashore, the shells being cast from 2½ to [illegible] ins. in thickness and each one of suitable length for its location in the pier. This shell served as the form for each cylinder, thus obviating the use of steel shells or other form devices in the water. The cylinders were spaced 12 ft. on centers longitudinally and 18 ft. on centers trans-



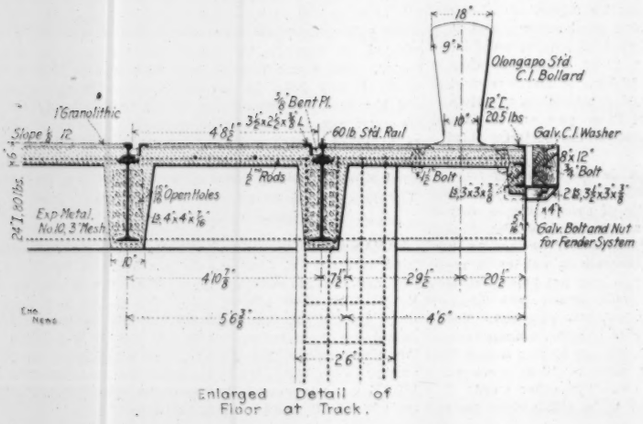


FIG. 1. TRANSVERSE SECTION AND PART PLAN OF REINFORCED CONCRETE PIER FOR U. S. NAVAL STATION, OLONGAPO, P. I.

versely of each pier. A steel framework connected the heads of the cylinders, 24-in. I-beam girders transversely of the piers for the 18-ft. spacing and 12-in. I-beams longitudinally for the 12-ft. spacing.

Reinforced-concrete construction was used for

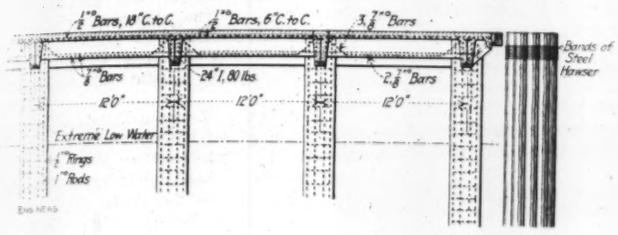


FIG. 2. LONGITUDINAL SECTION.

the deck or floor and for encasing the steelwork. Each 12 × 18-ft. panel was also supported by two reinforced-concrete beams thus making the clear span for the 6-in. top floor slab less than 6 ft. The vertical reinforcing rods of the concrete cylindrical shells were extended continuously up into the concrete mass of the pier deck, and were bent over the upper flanges of the steel framing, in most cases, to develop so far as possible the full value of the rigid connection between the supporting cylinder and the deck or floor construction.

Construction of Cylinders.

The time of completion being of primary importance to eliminate the risk which would be encountered if the critical part of the work should extend over into the typhoon season, a schedule of progress was mapped out for each stage of the work.

Previous to this an experimental section had been molded, and it was seen that the results obtained by casting or molding the concrete shell in one continuous operation were superior to and less expensive than the method of building up the shell by plastering with successive coats of cement mortar to secure the requisite thickness.

FORMS.—The casting process required that simple forms be devised that could be used repeatedly and quickly, otherwise a large number of them would be needed to maintain the necessary rate of progress. This was accomplished by making the external forms in two pieces longitudinally (Fig. 2), the lower semi-cylindrical shell being laid on a working bed or ways consisting of 6 × 8-in. wood sills spaced about 4 ft. c. to c., the outer rows being at a lower elevation to accommodate the bell ends of the cylinders, which were 4 ft. 6 ins. in diameter. On the upper half of the cylindrical form the sheathing at the top was omitted for a space sufficient to permit the cement mortar to be worked in from the top. The form sheathing consisted of ⅞ × 3-in. Douglas fir, dressed on the inside and the two edges, laid up tight and nailed every 4 ft. to the 2-in. external plank ribs that had been cut to form arcs of the required radius. The ribs were so placed as to stagger the ways or sills, thus permitting the cylindrical form to be rolled over without jar or strain to the freshly molded cylinders. The sills of the working bed were laid continuously out to the face of the shore abutment.

The interior surface of the concrete cylinders was obtained without the use of separate forms by the arrangement of the reinforcing materials. Looking at a typical cross section of the concrete shell, the eight 1-in. diameter longitudinal rods were placed 2 ins. in from the external surface of the concrete and wired to circular hoops of ½-in. rods spaced 12 ins. apart transversely to the longitudinal rods and the axis of the cylinder. To the inside of the hoops was secured No. 20 gage galvanized wire cloth having a rectangular mesh about 2½ per inch. Soft annealed wire, No. 16 gage, was used to tie the reinforcing together at all junctures, and the inner cylinder of wire cloth was thoroughly secured to the iron hoops. The wire cloth alone served the purpose of an inner form.

The rods and hoops, after being cut and shaped by the blacksmiths, were assembled adjacent to the site of the concrete forms, the cage of reinforcing steel and netting being made up complete before being set inside of them. To facilitate handling the concrete cylinders, the eight 1-in. rods were extended about 2 ft. beyond the upper limit of the concrete shell and the end of each rod was bent over to form an open hook. The lower ends of the rods were bolted to a circular ring angle iron which formed the cutting edge of the bell or enlarged end of the cylinder.

MOLDING CYLINDERS.—The reinforcing cage having been centered and suspended within the form, which was laid horizontally on the sliding ways, the cement mortar in the proportion of 1 part Portland cement to 2 parts sand was deposited from hand buckets through the continuous sector left open at the top of the form. By depositing the mortar on plates of light sheet metal above the reinforcing rods, the mortar was guided along until it dropped into the lower invert and came up against the wire-cloth mesh. While the mortar was being placed, the result obtained was visible to a workman inside of the cylinder who directed the working of the mortar to fill out the form uniformly at all points. The most satisfactory consistency of the mortar was soon learned, so that it was easily worked around the reinforcing metal, with just enough exuding through the meshes of the wire cloth to produce a key.

The man inside the cylinder used a trowel or float to smooth over the inside with the surplus mortar, filling up all voids or imperfections and leaving the wire cloth enclosed in it. Each cylinder was molded in one continuous operation; the horizontal type of form permitted the mortar to be deposited throughout the length of the cylinder, using as many men as could economically work on it at once. On an average from three to five cylinders were molded each day, depending upon their length.

For the first 48 hours the newly molded cylinder was wetted down at intervals and protected from the sun by tarpaulins, then the upper half of the form was taken off, the blocking against the lower half of the form removed, and the whole rolled over until the lower form released itself, leaving the concrete shell lying free on the sills. It could then be carefully rolled along on the ways toward the water front to remain until it was sufficiently cured to set it in position in the pier. The concrete shells were generally allowed to lie on the ways four weeks to cure.

Pile Foundations.

While the cylinders were being cast, the work of driving foundation piles for abutment walls and cylinders had been completed and the concrete laid in the abutment walls.

The piling for each cylinder consisted of a group of three piles driven until the heads did not project above the bottom surface more than from 6 to 12 ins., it being at the same time possible to encompass their heads within a circle not over 4 ft. in diameter. The piles were driven from a large floating driver equipped with a 3,000-lb. hammer and a heavy cast-iron follower. On account of the limited clearance between the inside of cylinder bell and the heads of the piles, particular care had to be exercised to insure the exact location of the first pile driven for each cluster. Its position was therefore established by a heavy plumb bob let down from the surface. A diver marked the position and when the pile was lowered, placed its point in correct position. When the pile had reached the foot of the leaders a follower pile was used to drive it the remaining distance. The behavior of the piles in being driven indicated the presence of materials of varying resistance. In all probability the sand contains strata of dead coral. Better results were obtained in maintaining the pile heads within the required circumscribed circle than had been anticipated and in only a few cases was it necessary to dispose of a pile, that had worked out too far, by driving it down below the

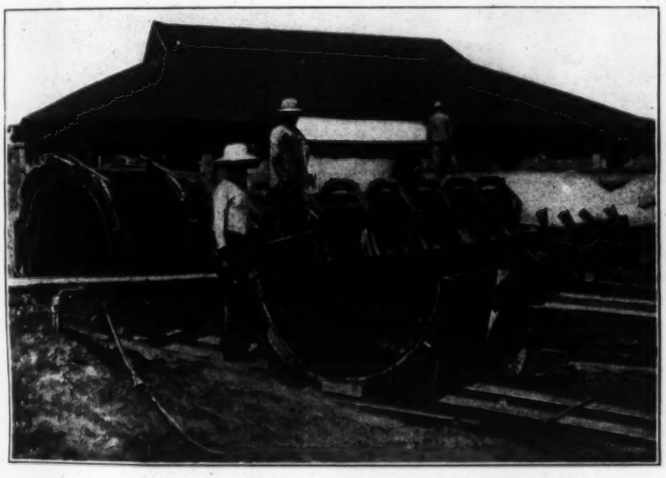


FIG. 3. FORMS FOR HOLLOW CONCRETE CYLINDERS.

FIG. 4. REINFORCEMENT FOR THE HOLLOW CONCRETE CYLINDERS FOR OLONGAPO PIER.

bottom and out of the way of the cylinder. In the case of the pier for the floating dock, a pile working trestle was first constructed parallel to the finished inner line of the wharf to afford stability to the cylinders.

Setting of Cylinders.

A 20-ton floating boom derrick was available for setting the cylinders. The cylinder was raised to a vertical position by a rope sling and then was suspended by chain rings hooked over the ends of the reinforcing rods, which, as previously noted, had been bent over for this purpose. Being suspended in this manner the cylinder hung vertically like a huge plumb bob, and by maneuvering the derrick, the cylinder was lowered into position over the foundation piles.

A water-jet pipe connected to a 2½-in. hose from fresh-water hydrant was then applied on the inside of the cylinder, along the cutting edge, to wash out the sand until the cylinder was worked down into position with the bottom edge from 2 to 4 ft. in the sand and below the top of the pile heads.

The cylinders in the deepest water were sunk by using the water jet from the outside in the hands of a diver; their greater weight, due to their length, aided the sinking.

It may be noted that the services of divers contributed materially to the prosecution of the work at certain stages. They were employed to advantage in the clear and warm tropical waters. The native divers required only helmets for their work and were obtainable at about the same rates of pay as other native skilled labor.

As the setting of the cylinders was accomplished a temporary staging of timbers was introduced to hold them at a proper spacing and to afford support to runways for handling concrete in filling the cylinders.

Depositing Concrete in Cylinders.

Some of the short cylinders in the row next to the abutment were filled by depositing a 1:2:4 moderately dry concrete through a tremie made of galvanized sheet iron about 14 ins. in diameter at the lower end, and 10 ins. at the top of the tube. The washing out of the cement occurring whenever the tremie was first charged, or after it had been lifted too high and the charge lost, indicated the advisability of applying some other method on the deep cylinders where a greater loss of cement would have occurred. A cylindrical bottom dumping bucket about 14 ins. in diameter by 5 ft. long had been constructed and it was found that by discharging through the bottom dumping bucket a layer of not more than 12 ins. of concrete at the base of the cylinder surrounding the pile heads, it was possible 48 hours afterwards to bail out the cylinders. The concrete shells were water-tight and the sealing of the bottom was generally so effectual that they often stood as bailed out for several hours, before the concrete filling was deposited.

For filling all cylinders in the dry a 1:2½:5 mixture moderately wet was employed, the aggregate consisting of cleaned gravel varying in greatest dimension from ¾-in. up to 4 ins. Each cylinder was filled continuously and rapidly up to a plane about 8 to 12 ins. below the location for the lower flange of the 24-in. I-beam girders. All told, 164 cylinders were cast and set and only one was lost through breakage in handling.

Superstructure.

A few days after the concrete filling had been placed in the cylinders preparations for setting the steel beams for the deck framing were commenced by cutting down the concrete shells, to permit setting steel work at proper elevations.

FORMS OF FLOOR CONSTRUCTION.—The system of forms for the intermediate reinforced-concrete beams, floor slab, and for encasing the steel framing, was designed so as to suspend a bottom form on the underside of the steel beams. U-bolts of ½-in. diameter were hung over the top of the beams through the form and the nuts were drawn up against a cross yoke of light angle iron made the full width of the form. The remaining sections of the forms derived their support from this lower base form and were all arranged for repeated erection.

The lumber used throughout was 2-in. Douglas fir dressed one side and two edges laid up close, and edges fully beveled 45° where re-entrant angles occurred between the beams and floor slabs. Sufficient forms were constructed to permit the laying of the concrete in each pier in three intervals.

REINFORCEMENT.—Plain round rods were used for all beam and floor slab reinforcement, but the material previous to placing in forms had been assembled on a unit system so that no time was lost in securing the steel in proper position while the concrete was being laid. The lower flanges of the steel beams were wrapped with wire cloth held away ¼-in. from the steel to afford a key.

DEPOSITING CONCRETE IN FLOORS.—Immediately upon the erection of the first section of forms, the placing of concrete was begun and maintained by working continuously three 8-hr. shifts until the entire set of forms was filled. Each shift laid on an average one transverse panel from the abutment to the water-front face, no concrete work being stopped, except against vertical screeds over the center of the steel girders. The main body of the concrete consisted of a 1:2:4 mixture, with the broken stone from ¾ to 1½ in. in size. Around the lower flanges of the steel beams and for the top finish of the floor, 1:2 mortar alone was used. The top coat was homogeneous with the concrete in all cases, and the floor was finished with the surface marked off into 6-ft. square panels and rolled with a toothed roller.

Joints for expansion and contraction were left about every fourth panel transversely the length of the structures over the 24-in. steel girders. Later these were washed with cement grout and filled with a soft mixture of sand and asphaltum pitch.

The forms were struck seven days after the concrete had been laid. The only place that difficulty was experienced in obtaining concrete dense and full to form occurred in places on the lower flanges of the 24-in. steel girders. Sounding with a trowel showed some hollow spaces that had to be cut out and replastered from the underside by masons.

The bollards were set at the same time as the concrete deck was laid and consisted of ⅝-in. steel plate cylinders with riveted single butt strap joints and an angle iron ring at the bottom for eight 1-in. diameter bolts that anchored around the steel girders. Reinforcing rods were also inserted inside the bollard and the whole filled up solid with concrete.

Loads, Stresses and Materials.

The principal loadings and unit stresses adopted in the designs of the piers were as follows:

Floor or deck load, 400 lbs. per sq. ft. for uniformly distributed live load for beams and girders.

Max. allowed load per pile, 15 tons.

Max. allowed compression concrete in bending, 600 lbs. per sq. in.

Max. allowed tension in steel, 16,000 lbs. per sq. in.

The structural steel reinforcing material, wire cloth and Portland cement was purchased in the United States. The structural steel was purchased under manufacturers' standard specifications. The reinforcing rods were of high carbon steel having an elastic limit of 50,000 lbs. per sq. in.

The piles consisted of various kinds of native hardwoods obtained on the naval reservation.

The government rock-crushing plant supplied the broken stone, the material being transferred by scows to the site of the work. The gravel was obtained from the beach on the west shore of Subig Bay, a distance of five miles by water. This gravel comes from a rock formation of harder material than is found in the quarry at the stone crusher, and was used therefore, principally in the concrete filling for the cylinders. An excellent graded beach sand was obtained at the mouth and bar of the Kalaklan River within a mile distant of the work.

COST.—Before undertaking the work by force account advertised proposals were invited for the erection of the piers exclusive of the pontoon bridge. The estimated cost was about $80,000, whereas by contract it would have cost about $16,000 additional. The actual cost by Government labor was less than $85,000, and it is estimated that a saving of over $12,000 was made on the total work. This represents an average unit cost of approximately $2.60 per sq. ft. of floor area. The actual cost to the Government includes overhead charges, such as cost of power, pay of office force and foremen, and leave pay for all employees engaged on the work.

FIG. 5. CASTING THE HOLLOW CYLINDERS.

Personnel.

The original design for this type of pier construction was developed by Civil Engineer Paul L. Reed, U. S. Navy, the officer in charge of public works in the year 1905, during the early part of his tour of duty on the Asiatic station. The plans were approved and the construction of the piers authorized by the Bureau of Yards and Docks early in 1907, an appropriation having been made by Congress in the interval. The actual work of construction was executed under the supervision of the writer as successor to the above officer at Olongapo, with Mr. R. B. Park as principal civilian assistant.

The improvements are a part of the general naval public works being built under the direction of *Civil Engineer R. C. Holliday, Chief of the Bureau of Yards and Docks, U. S. Navy Department.

*With the rank of Rear Admiral.

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The reinforced-concrete flat girder bridge resting on braced column bents is undoubtedly uneconomical and unsafe where the spans are so long or the columns so high that heavy longitudinal and transverse bracing is required. In smaller spans where the carrying girders themselves furnish sufficient longitudinal stiffness and the height of the structure is such that the bearing columns need no cross bracing, this type of construction has very great possibilities, particularly on account of the low figure at which it can be built. A very good example of such a structure is the Asylum Avenue viaduct at Knoxville, Tenn., which is described by Mr. L. W. Frierson on another page of this issue.

The views which we publish show that the viaduct satisfies the first requirement of a city bridge, namely, that it should be pleasing to the eye. For its location, in the midst of the city where lightness of line and unobtrusiveness are of importance, it is better adapted than the usually more pleasing, but in this case probably more cumbrous, arches. Incidentally, the viaduct has promise of long life, which is not altogether to be despised. And finally, according to the figures given out, it cost only $2.00 per sq. ft. of road surface between faces of abutments, and but $1.25 per sq. ft. if the long approaches be included. This latter figure cannot be used as a basis of comparison, since the size of the approaches and the material from which they are made will vary with every structure and in every locality, but the former figure of $2.00 per sq. ft. for a permanent, well-paved and sightly bridge, is remarkably low.

This low figure is partly due to the solid footings which involved small expense, but it is mostly a result of the type of structure, which results in such low dead loads and so economical a distribution of stresses. Possibly, a light ribbed arch construction might figure out equally as cheap, but the necessity for heavier piers to care for unbalanced loading would probably have raised the cost above that for the girder bridge.

We referred in this place last week to a boiler test in which an efficiency of 82.36 per cent. was attained, according to the figures furnished to us for publication; but in which also we found upon inspection that the figures for factor of evaporation did not agree with the data reported. Since our last issue appeared we have received a letter from the chief of the department under which the test was made, thanking us for bringing the error to his attention. He states that he finds upon investigation that the error went through undetected, because the Board which reported on the test did not, through a misunderstanding, check over the report of the testing engineer who made the error. With the error corrected, the boiler efficiency becomes only 74.26%.

There are morals in this story, for those who care to seek them. One moral, as to the painful results of publishing contributions without critical analysis, we pointed out last week.

Another moral is that the engineer should distrust any result which doesn't look right, even if it is the result of careful computation. Better go over the figures again; or, better still, have some one figure the thing independently, choosing his own method and see how nearly he agrees with you.

We are reminded also of the letter published in this journal a year or two ago by an employer of engineering graduates, who found that their work was full of errors; but the errors were blunders in arithmetic as a rule rather than engineering theory.

Betterments and improvements on electric interurban railways are likely to become important features in the work of such railways within the next few years, and in fact a beginning has been made already. In this respect the history and experience of lines of this character will follow closely upon that of steam railways, whose betterment work has been of great and increasing importance for several years. This includes such work as grade and curve revision, additional tracks, signal equipment, stations and terminal facilities, etc. The development in this direction is very natural, and may be expected with good reason, since many electric interurban roads operate a frequent service of both fast and local trains under such unfavorable operating conditions as excessive curvature, single track, absence of signals, etc. The improvements will be made partly to facilitate traffic and partly to give a greater degree of safety than is assured under present conditions. They will be made, also, partly on the initiative of the railways themselves (having regard for their own interests), and partly under pressure from public authorities.

As far as grades are concerned, electric railways can operate economically over steeper grades and more broken profiles than are desirable for steam railways, owing to their light loads and the direct application of the power. Nevertheless, the climbing of grades involves the consumption of power, in any case, and steep grades may be danger points. Sharp curvature has been used in construction too liberally in many cases, and its reduction is in many cases desirable for both safety and economy. One specially important reason for this on single track lines is the liability to collisions on curves, as experience shows that very many accidents of this kind occur due to the view of opposing trains being obscured. Although the primary reason in such accidents is in defective orders or disregarded orders, and an absence of block signals, the fact remains that the point of collision is very generally upon a curve. It is very probable that many similar accidents are averted through the opposing trains being visible to each other as they approach on a tangent and being stopped in time. In fact some electric railways build a double track on important curves for greater safety. The desirability of block signal equipment on railways of this character has been discussed editorially in previous issues, and we merely point out here the insurance value of such equipment and the possibility of obtaining efficient and reliable signals at reasonable cost.

Many improvements of the kind above referred to are desirable in themselves, but would cost more money than the companies can afford or more than they consider warranted by the results obtained. On the other hand, there are similar cases where the benefits are so evident as to lead the companies to undertake the work without much question. Elsewhere in this issue is described the revision of that part of an interurban line extending between a city and a pleasure resort park, the purpose being to facilitate the handling of a heavy traffic and to secure greater safety in operation. It may be predicted with confidence that work of this kind will increase, and will form a new field of activity for contractors and for engineers.

A brief note from the University of Arizona, published elsewhere in this issue, describes a novel experiment which is to be tried there in connection with the work of the junior and senior classes. As was recently shown in the discussion in these columns upon the amount of time spent in recitations in the average engineering schools, a student's time is pretty well taken up during the daylight hours by class-room work. So far as this work is in the drafting-room or the laboratories, the time, of course, is well spent; but it must be admitted that a good part of the time spent in the ordinary recitation room may be, and often is, wasted.

There are, of course, exceptions. In the class in mechanics, for example, a really able teacher can interest the whole class in discussion of the lesson for the day and can so shape the recitation, the questions and the class-room work that it will help even the bright student to fix in his mind the subject which is being considered. If this were the rule, it would be difficult to make any change for the better; but we fear it is not the rule. In too many cases the time in the class room is chiefly devoted to trying to give the duller members of the class some glimmering idea of what the subject is all about. The brighter members, who have really mastered the subject already, have to sit and listen to the attempts of the teacher to drill into the minds of their duller brethren a conception of the subject. In such cases it must be admitted that the brighter men of the class might be using their time much more profitably.

There is another evil pertaining to work done under an instructor. The tendency always is for the student to lean on the teacher, instead of mastering the subject unaided. He must work out his problems alone after he gets out of college, and he ought to become accustomed to it while he is in college. Of course, a great deal of ground can be covered by a student working with the aid of a capable tutor or instructor, but after he has done the work he will not be nearly as well fitted, nor nearly as competent a man, as the slower worker who has dug out the whole thing for himself.

The new plan proposed at the University of Arizona for the junior and senior classes is to allow the students to spend their time in study. Once or twice a week a student will meet his instructor, to consult with him as to his work, and at times lectures may be given. This new method of instruction presupposes, of course, bright students and industrious students, who will be willing to buckle down to work the week through without supervision or prodding. But that is exactly the kind of students that ought to be found in an engineering school. We believe the Arizona plan is worth thought by those who are teaching engineering in larger institutions.

Concerning "Good" Corporations and "Bad" Corporations, and How to Reform the Latter.

The City of New York is in a quandary. Through its official representatives, the Public Service Corporation, it has received bids for the construction of a new system of underground rapid transit lines, the so-called "Triborough system." Since these bids were received, the Hudson Companies, of which Mr. William G. McAdoo is President, have offered to enter into a contract for the construction and operation of the Triborough System, but considerably modified in its layout from that originally adopted. Mr. McAdoo's offer has received general approval, and he has requested that action be taken upon it not later than Dec. 15.

Since Mr. McAdoo's offer was made, however,

the Interborough Co., which controls the present subway and the Manhattan elevated lines, has "seen Mr. McAdoo and gone him several better." To state the case in more conventional terms, the Interborough has now come forward with an offer to the city to construct extensions of its system on a large scale which will give added transit facilities equal to or approaching what the Triborough System, as modified by Mr. McAdoo, would have furnished. Further, it proposes to put $75,000,000 of its own capital into this work.

We shall not here attempt to pass critical judgment upon the relative merits of the two propositions. We may assume, however, that the Interborough proposal is, all things considered, the most advantageous for the city because this is substantially admitted by a number of the New York newspapers who are most strongly opposed to dealing with the Interborough Co. As announced last week, a Citizens' Committee has been created at the suggestion of Mayor Gaynor to investigate the whole matter of additional subways, and the offers which have been made. While this committee is an entirely unofficial body, its report will doubtless have great influence upon the Public Service Commission and the City's Board of Estimate in reaching final decision as to what the city shall do.

The question which seems worth some general discussion here is the question as to the policy which should be pursued in dealing with a great public utility corporation. Assume that the McAdoo offers and the Interborough offer were equally advantageous. Should the city close with Mr. McAdoo because his corporation is a "good" corporation, or turn down the Interborough's proposal because it is, in popular estimation at least, a "bad" corporation?

It has been suggested by high authority that there are good trusts and bad trusts. Should the moral quality of a trust or a corporation be taken into account in doing business with it? This raises the interesting question whether a corporation, strictly speaking, has any moral quality. Proverbially, a corporation has no soul, and being thus freed from the pains and penalties of a future state it might reasonably be expected to be lacking in moral responsibility. On the other hand, corporations are administered by men with entirely human (or inhuman) qualities, and the corporations they conduct partake of those qualities, not only in the popular mind but practically.

Every experienced business man knows that it is always unsafe to do business with a dishonest man. A well managed business concern will not sell goods to a "dead beat," nor will it purchase from a concern of shady reputation. It will not employ, in any capacity, a man who is known to be dishonest.

Further than this, in carrying on business, the moral character of men of different degrees of honesty is properly taken into account. If it is a question of letting a contract to one of two bidders where one of them is a man of known high integrity whose word is as good as his bond, he will very likely be given preference over a competitor who has merely a reputation for ordinary honesty.

The same rule holds good in the case of corporations of ordinary size, where one man or a few men hold a controlling interest and dictate the policy of the company. There is no doubt at all as to the wisdom of taking moral quality into account in dealing with corporations such as these. But when we reach the corporations of the size that control public utilities in our great cities, it is a question whether we have not passed the stage where the moral quality should govern the public in its dealings. Who are the real owners of the Interborough corporation, for example? They are the thousands of holders of its stock and bonds. In moral quality there is no difference between these actual owners of the Interborough corporation and those who own the securities of the Hudson Companies, represented by Mr. McAdoo.

If, then, the Interborough is really a "bad" corporation, if it contumaciously neglects to carry out the orders of the Public Service Commission, if it does for the public the least it possibly can and tries to exact the greatest return in revenue with the poorest service, if these allegations are true, it is not the thousands of Interborough stockholders who are to blame; it is the officers who happen to be at the present time in control.

Right here lies the chief reason why a city cannot safely grant a franchise to one corporation because it is "good" or withhold it from another because it is "bad." The "good" corporation may be under the control of an entirely different set of men a year or two years or ten years hence and be then as devilish as it now is saintly. On the other hand, the "bad" corporation may be reformed and become a model of enterprise and efficiency. Now in granting a franchise we are entering into a contract for a period perhaps of 25 to 50 years. It is not wise, therefore, to be governed by the moral quality of a corporation's present management, in making a contract to run for such a time.

It is, therefore, it seems to us, short-sighted to say that the way to punish a "bad" corporation is to refuse to grant it franchises. The really vital question is, how can a "bad" corporation be reformed and made a "good" corporation?

This is a question of direct practical interest to nearly every city in the United States. Competition in the operation of municipal public utilities, street railways, gas, electric light and the like is practically ended. In nearly every city in the country a corporation is in control of all these necessities of daily life. If the corporation is well managed, the public, as well as the corporation's stockholders, are benefited. If it is badly managed, both of them suffer.

Many good citizens of New York believe the Interborough should be punished for past misdeeds by refusing to allow it any further privileges or franchises and confining its business to the system which it at present controls. But this punishment will not better the management of the Interborough in any way, and the bulk of the rapid transit facilities of New York City are in its hands. It is a live question in New York, therefore, how to reform the management of a "bad" corporation.

There are two solutions of this problem which have been widely adopted. The first solution, which has been generally put into effect in European countries, is to do away with franchise corporations entirely and have the city itself undertake the ownership and operation of its public utilities.

In the United States, we shrink from this radical step. Instead, progressive states like Massachusetts, New York, Wisconsin and Texas are trying the experiment of controlling these corporations through state commissions, which are given broad powers of supervision and inspection.

It is admitted on all hands that this system is an experiment. It is not yet certain whether it will be possible for our public service commissions, with their great responsibilities and overwhelming volume of work, so to reform the administration of our public utilities as to satisfy the public demands.

That great improvements have been brought about through the efforts of these commissions is generally admitted by every impartial student. It is also evident, however, that their work is often carried on under great disadvantages. The success of the commission's work varies greatly, experience has shown, according to whether the corporation with which it is dealing is "good" or "bad." It depends, in other words, on whether the managers of the corporation are willing to meet the commission half way—whether the managers are really desirous of giving good service to the public or are chiefly concerned in exploiting the public.

As it is sometimes alleged that the Public Service Commission laws of New York, Wisconsin and other states are too drastic in the control over corporations, it may be well to see how Canada has treated this problem. The laws of Ontario creating the Railway and Municipal Board provide that when the Board orders a street railway company to do certain things:

> The board may take such steps and employ such persons as may be necessary for the proper enforcement of such order, and in pursuance thereof they may forcibly or otherwise enter upon, seize and take possession of the whole or part of the railway, and the real and personal property of such company, together with its books and offices, and may, until such order has been enforced, assume and take over all or any of the powers, duties, rights and functions of the directors and officers of such company, and supervise and direct the management of such company and its railway in all respects, including the employment and dismissal of officers and servants of the company for such time as the board shall continue to direct such management.

This looks like a prompt and effective method of reforming the management of a "bad" corporation; but on the other hand so drastic a procedure, it is evident, would only be undertaken as a last resort. The greatest difficulty of our public service commissions is not with the corporations, which are so "bad" that their managements should be promptly beheaded. It is the corporations which are slow to obey, which have to be prodded to get them to cooperate in giving improved public service, that give greatest difficulty to the Commission.

And this leads to the suggestion that the greatest weakness in the Commission plan of corporation control is that the Commission works on the *outside*. For the most effective regulation the work should be done on the *inside*. The proposal has been made, therefore, that on the board of directors of every public utility corporation there should be one or more representatives of the public. These "municipal directors" might be appointed by the mayor or the state public service commission, but their duty would be to see that the affairs of the corporation were conducted in a manner open and above board, in accordance with the law and with due regard to the rights of the public as well as the rights of the stockholders.

Admittedly, such positions would be most difficult to fill. Men of the caliber, backbone and tact required to successfully carry out such work are rare. On the other hand, such administration seems to offer the greatest hope of real improvement in the conduct of our public utility companies.

It is a very difficult thing by any form of punishment to transform a scapegrace youth into an industrious and docile boy. Some of our public service commissions are finding it extremely difficult by any form of punishment within their power to make a contumacious corporation management give to the public the good service to which the public is entitled. To fine a corporation for smoking chimneys, or delayed trains, or insufficient car service, or poor quality gas very often arouses antagonism, and the corporation managers sit back and refuse to do anything whatever for the public except what they are compelled to do.

That attitude by a public utility corporation is always bad for the public, no matter how efficient the Commission placed over it or how broad its powers.

On the other hand, if upon the Board of Directors of every company operating a public utility there were placed one or two high-class men representing the interests of the public, men with proper qualities of tact and leadership, it should be possible to infuse real zeal for good public service into some corporations which are now generally classed by the public at least among the goats.

This is not a new suggestion. In fact under one form or another the experiment of municipal representation on corporate boards, is being tried. In Philadelphia, we believe, representatives of the city now sit on the street railway board of directors. The most notable experiment, however, is Chicago, where the whole street transit system is being rebuilt under direction of an Engineering Board on which there are representatives of both the city and the street railways.

The work of this Board has been so conspicuously successful that it is an object lesson to other cities. Admittedly much of the success at Chicago is due to the city's good fortune in having a man with the strong personality and high ability of Mr. B. J. Arnold as its representative; but part of the success also we believe, is due to the fact that it is regulation from inside instead of from the outside.

LETTERS TO THE EDITOR.

The Imhoff Sewage-Clarification Tank.

Sir: I have just read with great interest the article in your issue of Dec. 1 on the Imhoff Sewage Purification Tank, by Mr. Chas. Saville. While the article is most ably prepared and shows very conclusively the satisfactory solution of the sewage disposal problem in the Emscher drainage area it would seem pertinent to call attention to the fact that the Imhoff tank, like the septic tank, is not in itself a means of sewage purification but merely a preliminary or preparatory process and can be counted upon only to remove a portion of the suspended solids. The writer has again and again found it necessary to explain away the popular fallacy that septic tanks render sewage "pure," and it is well to guard against an enthusiasm for the Imhoff tank which may implant similar incorrect notions in the popular mind.

In the Emscher drainage area, where the streams that receive the sewage effluents are small, the final purifying treatment may be considered as taking place in the long concrete-lined and fenced-off artificial channels which replace these streams. This final treatment is rendered possible by the fact that these streams are not used for any purpose for which clean or even moderately clean water is required. In fact, conditions are such that use of the water in the channels may be deliberately precluded by fencing as above noted.

In the United States small streams are frequently used for cattle watering and other purposes on farms, for which reason the discharge of sewage into them is only permissible after a rather complete treatment which will render the effluent clear and inoffensive. In some cases even a final disinfection may be a reasonable requirement. If such a high degree of purification as this proves impracticable, owing to excessive cost, it is but fair that the community using the stream for the final disposal of its sewage should pay a reasonable price for complete control over a stretch of the water course in which a proper degree of self purification may take place. Moreover, nuisance must be prevented by suitable preparation of the channel to promote rapid flow and prevent accumulation in pools.

It would have been interesting to those readers who do not have ready access to the publications mentioned in the foot notes if Mr. Saville had given a brief description of the design of the sludge drying beds together with a statement of areas required. A more comprehensive statement as to the method of determining the size of the sludge wells would also have been of advantage.

In conclusion, the writer wishes to express the opinion that Mr. Saville's article and Mr. Hering's introduction thereto, is the most illuminating contribution on the sewage treatment problem that has appeared in the United States in several years.

Very truly yours,

Paul Hansen,

State Sanitary Engineer of Kentucky.

Columbus, Ohio, Dec. 7, 1910.

The Strength of Old Timber.

Sir: I read with great interest the article by Mr. C. P. Buchanan in your issue of Dec. 8, "Some Tests of Old Timber," and your editorial comment on the same.

There is no doubt that many men who have spent the best part of their lives in building heavy timber structures, and have become master or foreman carpenters of the highest class, together with many engineers, hold as a fact that wood loses its "life," becomes "dead," "brashey" or "short." It is perhaps equally true that many men of equal opportunity for observation believe that iron loses its strength in service due to "crystallization." This latter belief is not shared by men who have made a scientific study of this matter, and it may well be that the former belief can be finally disproved by the same methods.

Mr. Buchanan's test goes part way in furnishing such a proof, but one must regret that he did not also make tests in tension, or in compression on specimens long in comparison to their cross section. For it would seem that such tests, rather than compression tests on short blocks such as made, might be expected to bring to light a loss in strength due to the fiber becoming "brash" or "short."

The writer has in mind a white oak lower chord in a roof truss of an old church, which failed, presumably in tension, after many years of service. The wood appeared perfectly sound and was certainly harder than fresh oak used for such work, but the fracture was almost at right angles to the grain and there was no splintering, the projecting fibers being remarkably short, scarcely half an inch if recollection may be relied on.

Such examples as this have given rise to the belief that timber may lose its strength after long service, apart from decay.

The writer has heard this explained by the statement that the wood dries out, but tests on comparatively fresh timber show that, to a certain point at least, the strength of wood increases direcly as the moisture content is reduced. Of course such examples as that cited may be explained as the "crystallization" of iron has been. But the case seems to be still open.

Very truly yours,

Charles H. Higgins.

Commercial Trust Bldg., Jersey City, N. J., Dec. 8, 1910.

Responsibilities of Contractors in Making Shipments of Explosives.

Sir: Through your valuable Journal I would like to bring to the attention of contractors generally a matter of great importance to them and to the traveling public.

All shipments of explosives must be made strictly in accordance with federal laws, for the violations of which, the penalty is a fine not to exceed $2,000, and imprisonment not to exceed 18 months. These laws will be found in Sections 233 to 236, inclusive, of the Act of Congress of March 4, 1909, and in the regulations of the Interstate Commerce Commission for the transportation of explosives in interstate commerce promulgated in conformity with Section 233 of the Act cited. It is absolutely essential that all shippers of explosives should become thoroughly familiar with these regulations. A copy can be obtained from any railway agent, and information in regard to any doubtful point will be cheerfully furnished by the "Bureau of Explosives, American Railway Association, 24 Park Place, N. Y. City."

The rules prescribe in detail the qualities of boxes and kegs used for the shipment of high explosives and black powder, the markings that must be on these packages, the names that must be used in describing the shipments on shipping orders, and the certificate that the shipper must furnish on his shipping order. The explosives must be in proper condition for safe transportation and the packages must be in good order. Unless this be true, and unless all other rules are complied with, the shipper cannot truthfully sign the certificate required of him.

The manufacturers of explosives and the caretakers of storage magazines throughout the United States are now conversant with these rules and, as a rule, are complying with them. The principal danger of disastrous explosions in transit seems now to accompany the shipments of explosives offered by contractors. Many of these gentlemen obtain explosives in good condition from the factories, or storage magazines, and do not provide proper storage facilities for these explosives while in their possession. Exposure to dampness and to elevated temperatures is liable to cause deterioration in explosive packages and in their contents. The wood pulp and nitrate of soda used as an absorbent for nitroglycerin in dynamite are hygroscopic and will absorb moisture from the air readily. In proportion to this absorption, the nitroglycerin has a tendency to exude from the cartridges. When it does this, it will be absorbed by the wood of the dynamite box and is liable to leak through the joints. There can be no more serious violation of the rules than to offer for shipment a box of dynamite in this condition. The same kind of exposure results in rusting of black powder cans and the opening of their seams. As soon as a leakage of black powder from one of these packages occurs in a car there are many ways in which ignition of the material can result. In one case loose powder from such leakage escaped through a crack, or nail hole, in the floor of a car in a freight train standing on a siding, and the powder was blown by the wind toward the main track. Sparks from the fire box, or the brakes of a passing locomotive, ignited this train and the entire shipment of powder exploded while a passenger car was in the immediate vicinity. All of the passengers in the car were either killed or injured.

A contractor doing work on a railroad applied to the railway agent for billing to ship his outfit of five cars to another point on the road. He said nothing about having explosives in his outfit. One of his cars contained a large amount of both dynamite and black powder. The car was in bad condition and contained many holes and cracks through which hay, on the floor of the car, protruded and offered an excellent opportunity for ignition by sparks from locomotives. The packages were leaking and a large amount of loose powder was on the floor mixed with this hay. Upon arrival at destination no mention of the contents was made to the agent at that point, and the car was permitted to stand for a number of days on a siding near the main track where it was exposed to this constant danger of ignition from passing locomotives. Through carelessness of the contractor's representatives an explosion did finally occur during the unloading of this car, which resulted in the deaths of two men and one child.

Two causes have been reported recently to the Bureau of Explosives showing the extreme carelessness of contractors that it is hoped this communication will help to remove. One of them shipped on a flat car miscellaneous materials, including a tin bucket containing 14 cartridges of dynamite of high strength. Another contractor shipped a box of tools and placed in this box three boxes containing 50 lbs. each of dynamite, together with a number of blasting caps. There was nothing in the marking of these packages to indicate the serious violations of the law involved in these shipments.

It is the intention of the Bureau of Explosives to prosecute vigorously violations of this kind and this letter is written in the hope that it will impress upon contractors generally their moral and legal responsibilities in making these shipments.

Very respectfully,

B. W. Dunn,

Chief Inspector, Bureau of Explosives,

Am. Ry. Association, 24 Park Pl., N. Y. City.

Dec. 8, 1910.

Short vs. Long Headings in Tunnel Driving.

Sir: After an exhaustive study, here and abroad, of the problems involved in driving long tunnels, the writer has been prompted by the letter of Mr. Geo. C. McFarlane, published in Engineering News of Sept. 29, 1910, to present the following notes.

Although it is not the purpose to criticize that gentleman's suggestions, several of which, though novel, are undoubtedly possible of execution and deserve the careful consideration of tunnel contractors, yet the writer wishes to point out that the experience gained during the past decade has demonstrated that the successful methods for driving long, deep tunnels are nearly the opposite of the methods suggested by Mr. McFarlane. This applies especially to the methods of attacking the full section of the tunnel, as compared with attacking only a long heading of small cross-section.

Driving a tunnel to its full cross-section can be compared to a shaft sunk without preliminary borings, or to a foundation being built to rest on unknown strata.

Let the reader be briefly referred to the three distinct methods used for driving large tunnels through rock in this country at the present time. The one most generally used consists in taking out a top heading, having usually the size of the tunnel arch, and then a lower part or bench carried 15 to 30 ft. back of the heading face. The second method, used to a smaller extent, consists in driving a top heading some 80 to 100 ft. in advance of the bench. The third method, sometimes adopted, consists in driving a heading only, from portal to portal or to a shaft, and then taking out the bench.

Without much exaggeration it can be stated that the above described methods have proved to be practically a failure, from the standpoint both of increasing speed, and of excavating at a low cost. Lack of space prevents the writer from discussing to some length the merits and disadvantages of the above described methods; yet a few words will point out their principal weak points.

In the first method, any delay in carrying forward the heading will affect the bench work, thus practically tying up the whole work.

The bench length carried in the second method will, to some extent, lessen this trouble; but, on the other hand, the long muck haul, usually accomplished with wheelbarrows, will be a hindrance to rapid mucking; besides, work at the bench will have to be stopped during blasting at the heading and vice-versa.

The third method has so far proved to be very expensive; this is obvious, for it costs but very little power to run two or three drills on the bench in addition to the drills in the heading. The superintendence and overhead charges will practically be the same in both cases, and the only real advantage gained lies in the better ventilation obtained after the headings have met.

If those methods have until now been used and are still in use, it is only for the reason that most of the railway tunnels hitherto driven in this country have been rather short, and that expensive construction shafts have often been sunk solely for the purpose of obtaining several working points. The time has come, however, when long tunnels will be driven through high mountains, excluding the possibility of sinking shafts or of using the rather crude tunneling methods so far adopted.

In tunnel excavation work it is a well-known fact that the driving of the headings is the costliest item, as compared with bench or enlargement work. A change in driving methods would therefore call for a reduction in size of the heading to a minimum. This reduction should not, however, be carried to an extreme, for experience has showed that headings or drifts of small section are expensive to excavate. A heading should have a height such as will enable a man to walk in it comfortably; its width should be such as to allow a narrow-gage track to be laid, together with sidings at such intervals as may be required, or which will permit four or five drills to be run in the breast of the heading; and the area should be such, that the air required for effective ventilation will not acquire too high a velocity.

The heading should be located preferably at the top of the tunnel, especially in soft rock; for a bottom heading can only be used advantageously in firm material with horizontal strata. The top-and-bottom-heading system will not be found very effective as to cost where a steam shovel can be used for handling the bench muck; this owing to the fact that the upraises or vertical drifts are very expensive to drive, as well as the starting of

the top headings, as used for instance in the Simplon and Loetschberg tunnels. In such material, however, where great pressures forbid the driving of large size headings, this method will prove to be very effective, especially if timbering material is at hand.

Wherever a heading is driven, it should be of such length as will enable all mining operations to go on without interruption or interference with each other.

The heading has, with some truth, been called the tunnel contractor's nightmare. Why? Because a heading successfully driven means a tunnel practically driven. This is obvious for a heading will show what the geologist has been unable to predict, i. e., exactly what kind of material is penetrated, the dip and the strike of the strata penetrated, the exact heat of the rock (so often underestimated), and the quantity of water to be taken care of; in other words, it will be the contractors "pilot." Especially in countries where preliminary studies must be reduced to a strict minimum, and where the geological conditions cannot be very carefully studied, will the long-heading system prove to be a saver of both time and money. This remark naturally applies to tunnels of some 5,000 ft. length or over, and where the depth of the overlying material is such as to prevent the driving of deep and expensive borings.

A heading can be started a long time before the whole tunnel plant has been installed, as only a few men and little power are necessary. After 500 or 700 ft. have been driven, the contractor will have more accurate information as to the hardness and brittleness of the rock, although the character of the rock may change as driving progresses; he will, however, have all opportunity to select to better advantage the type of the balance of the drills and appurtenances needed.

If the temperature of the rock penetrated, or injurious gases, are such as to be a hindrance to work, the contractor will be in a position to place orders for an adequate ventilating system. Should soft rock be encountered, he will be able to purchase in advance enough timber to take care of the pressure exerted, or if deemed necessary design steel frames. The heading having revealed the intensity and direction of the pressure, the engineer will be able to design the lining required to resist such pressure for decades, if not for ever.

A book could be written on the advantages gained by the use of driving long headings. To illustrate one striking example where lives, time and money were saved by the use of a long heading, let the reader be referred to the Loetschberg tunnel, now in course of construction. Up to July 24, 1908, the tunnel had been driven 8,774 ft. from the south portal; of this length some 6,000 ft. was heading. On this date a cave-in occurred, and within ten minutes some 9,000 cu. yds. of wet sand and boulders filled the heading for a length of 4,900 ft. Twenty-five men were killed outright. After a short suspension of work, during which it was decided to insert a reverse curve in the tunnel, in order to be able to drive through solid rock, work was resumed. All told, 4,000 ft. of heading had to be abandoned.

Had the tunnel been driven to its full section, the loss would have been $720,000, the cost per lineal foot of tunnel being $180, exclusive of tracks and installations, and the loss of life would have been appalling. One-twelfth of this sum represents about the cost of the heading. The loss was therefore but $60,000, to which sum must be added the cost of insurance paid for the victims of the accident, about $30,000, and the cost of the construction plant, buried forever under tons of sand and boulders mixed with dynamite cartridges and exploders, which had been stored in the tunnel. Without splitting hairs, it can safely be said that a sum of $500,000 was saved by driving the heading in advance of the enlargement. The total cost of the tunnel being estimated at $10,000,000, the contractor's profit would by this accident have been lessened 5%.

Such figures are sufficiently eloquent to make many a contractor change his mind about the choice of the method to be used for driving long tunnels, even though the accident above referred to was unique in character. Even though thorough geological study be first made of any proposed long tunnel, accidents of this kind and of equal or greater damaging effect may be repeated.

Eugene Lauchli.

2 Wall St., New York City, Nov. 18, 1910.

Notes and Queries.

A new rendering of the engineering term "cofferdam" has been discovered in Ohio. A. D. W., of Cleveland, Ohio, sends us a picture postal-card on which is printed the following title: "Lock 26 Near Gallipolis, Ohio. Coffee Dam Showing Battery of Boilers." A. D. W. suggests that the boilers are, doubtless, to boil the coffee!

A CONCRETE FLAT-TOPPED CULVERT, about two miles west of Grinnell, Iowa, collapsed on Nov. 23, on the removal of the forms. It had been completed about two weeks at the time, but the work had been done during intermittently freezing weather and it is assumed that the concrete had not had time to set up. The culvert had a 10-ft. span, was 40 ft. long and consisted of a 10-in. flat slab reinforced with ½-in. round rods (spacing not known). There was a 7-ft. fill of earth over it.

The Development of the Air-Brake: Presidential Address at the Annual Meeting of the American Society of Mechanical Engineers.*

By GEORGE WESTINGHOUSE,† President Am. Soc. M. E.

My first idea of braking apparatus to be applied to all of the cars of a train came to me in this way: a train upon which I was a passenger between Schenectady and Troy in 1866 was delayed a couple of hours due to a collision between two freight trains. The loss of time and the inconvenience arising from it suggested that if the engineers of those trains had had some means of applying brakes to all of the wheels of their trains, the accident in question might have been avoided and the time of my fellow-passengers and myself might have been saved.

The first idea which came into my mind, which I afterwards found had been in the minds of many others, was to connect the brake levers of each car to its draft-gear so that an application of the brakes to the locomotive, which would cause the cars to close up toward the engine, would thereby apply a braking force through the couplers and levers to the wheels of each car. Although the crudeness of this idea became apparent upon an attempt to devise an apparatus to carry the scheme into effect, nevertheless the idea of applying power brakes to a train was firmly planted in my mind.

Shortly afterwards, while I was in Chicago, the Superintendent of the Chicago, Burlington & Quincy R. R., Mr. A. N. Towne, invited me to inspect what was then considered an ideal passenger train, namely the Aurora Accommodation. I accepted this invitation and while looking over the train, which was fitted with a chain brake, I was introduced by Mr. Towne to Mr. Ambler, the inventor of that brake. The Ambler brake, as was explained to me, consisted of a windlass on the locomotive which could be revolved by pressing a grooved wheel against the flange of the driving-wheel to wind up a chain which extended beneath the entire train over a series of rollers attached to the brake levers of each car and so arranged that the tightening of the chain caused the brake-levers to move and thereby apply the brake shoes to the wheels.

I ventured to say to Mr. Ambler that I had been working upon a brake myself, but was immediately informed by him that there was no use working upon the brake problem, because he had devised the only feasible plan, which was fully protected by patents. Mr. Ambler's opinion and advice, however, proved to be an incentive to a more energetic pursuit of the subject.

As an improvement on Mr. Ambler's plan, I considered the use of a long cylinder to be placed under the locomotive, the piston of this cylinder to be so connected to the chain that it could be drawn tight by the application of steam from the locomotive boiler with a force which could be more accurately controlled than was possible with the windlass arrangement. A short study of this idea showed that it would be impossible to have a cylinder long enough to operate a chain brake upon more than four or five cars, whereas trains of ten and twelve passenger cars were frequently run upon important railways.

My next thought was the placing of a steam cylinder under each car with a pipe connection extended from the locomotive beneath its tender and under each car, with flexible connections of some sort, not then thought out, so that steam could be transmitted from the locomotive through the train pipe to all of the cylinders; but, as in the case of the attempt to improve the chain brake, it required but little time with some experimentation to disclose the fact that it would be impossible, even in warm weather, to successfully work the brakes upon a number of cars by means of steam transmitted from the locomotive boiler through pipes to brake cylinders.

Shortly after I had reached this conclusion, I was induced by a couple of young women who came into my father's works to subscribe for a monthly paper, and in a very early number, probably the first one I received, there was an account of the tunneling of Mount Cenis by machinery driven by compressed air conveyed through 3,000 ft. of pipes, the then depth of that tunnel. This account of the use of compressed air instantly indicated that brake apparatus of the kind contemplated for operation by steam could be operated by means of compressed air upon any length of train, and I thereupon began actively to develop drawings of apparatus suitable for the purpose and in 1867 promptly filed a caveat in the United States Patent Office to protect the invention. In the meantime, I had removed from Schenectady to Pittsburg, where I met Mr. Ralph Baggaley, who undertook to defray the cost of constructing the apparatus needed to make a demonstration.

At that time no compressed air apparatus of importance had within my knowledge been put in operation. The apparatus needed for a demonstration was, however, laboriously constructed in a machine shop in Pittsburg, being finally completed in the summer or early autumn of 1868. This apparatus consisted of an air pump, a main reservoir into which air was to be compressed for the locomotive equipment, and four or five cylinders such as were to be put under the cars, with the necessary piping, all so arranged that their operation as upon a train could be observed. In this way officials of the Pennsylvania and Panhandle railroads were then invited to inspect the apparatus and witness its operation. As a result, the Superintendent of what was then known as the Panhandle Railroad, Mr. W. Card, offered to put the Steubenville accommodation train at my disposal to enable me to make a practical demonstration. The apparatus exhibited was removed from the shop and applied to this train, which consisted of a locomotive and four cars. Upon its first run after the apparatus was attached to the train, the engineer, Daniel Tate, on emerging from the tunnel near the Union Station in Pittsburg, saw a horse and wagon standing upon the track. The instantaneous application of the air brakes prevented what might have been a serious accident. The value of this invention was thus quickly proven and the air brake started upon a most useful and successful career.

Prior to the construction and practical test of the air brake, I had opportunities while traveling to present the subject to numerous railway officials and to endeavor to secure their cooperation in the development of the apparatus. None of those approached appeared to have faith in the idea, though I afterwards found that the acquaintances made and the many discussions I had had with railway people were of great advantage in the introduction of the air brake upon the railways with which they were connected.

I suppose many persons present have heard or read the story of an alleged interview between Commodore Vanderbilt and myself about the application of air-brakes to the New York Central. The story as told seems to have appealed to the imagination of many people. As a matter of fact, there is no foundation whatever for that story. From the moment when the practicability of air-brakes was demonstrated to the present hour, there has been nothing but satisfaction and pleasure in being associated with an invention which has contributed so much to the safety and comfort of travelers and so greatly to the prosperity of railways.

In the development and introduction of the air brake, I was controlled by the apparent fact that the apparatus would have to be uniform upon all cars to provide for the convenient change of the composition of trains. It also was most obvious, in view of the crying demand for some better means for stopping trains, that some power brake would inevitably be universally applied to all of the cars and engines upon all railways. These ideas naturally involved a further one, namely, the importance of having all of the brake apparatus made by one company, so as to insure absolute uniformity and consequent interchangeability, and this led to the formation of the Westinghouse Air Brake Co. early in 1869.

The essential parts of the air brake as first applied were:

An air-pump driven by a steam engine receiving its supply from the boiler of the locomotive;

A main reservoir on the locomotive into which air was compressed to about 60 or 70 lbs. pressure per square inch;

A pipe leading from the reservoir to a valve mechanism convenient to the engineer;

Brake cylinders for the tender and each car;

A line of pipe leading from the brake valve under the tender and all of the cars, with a pipe connection to each brake cylinder;

Flexible hose connections between the cars provided with couplings having valves which were automatically opened when the two parts of the couplings were joined and automatically closed when the couplings were separated, so that the valve of the coupling at the end of the train was always closed and prevented the escape of air when introduced into the brake pipe.

The piston of each cylinder was attached to the ordinary hand-brake lever in such a manner that when the piston was thrust outward by the admission of compressed air, the brakes were applied. When the engineer had occasion to stop his train, he admitted the air from the reservoir on the locomotive into the brake cylinders through the train pipe. The pistons of all cylinders were, it was then supposed, simultaneously moved to set all of the brakes with a force depending upon the amount of air admitted through the valve under the control of the engineer.

To release the brakes, the handle of the brake valve was moved so as to cut off communication with the reservoir and then to open a passage from the brake pipe to the atmosphere, permitting the air which had been admitted to the pipes and cylinders to escape.

The success of the apparatus upon the first train was followed by an application of an equipment to a train of six cars on the Pennsylvania R. R., and in September, 1869, this train was placed at the disposal of the Association of Master Mechanics representing numerous railways, which association was then in session at Pittsburg. The train was run to Altoona and the air brakes were used exclusively for controlling the speed of the

*Delivered before the Society Dec. 6, 1910. Slightly condensed from the original.

†Pittsburg, Pa.

trains on the eastern slope of the Alleghenies, and special stops were made at the steepest portions of the line in such an incredibly short distance (as we all thought then) as to firmly establish in the minds of all present the fact that trains could be efficiently and successfully controlled by means of brakes operated by compressed air.

The next event of importance was the application of the brakes in November, 1869, to a longer train of ten cars upon the Pennsylvania Railroad, which was taken to Philadelphia for the purpose of demonstrating to the directors of that railway the success of the apparatus. I may say at this point that the Pennsylvania R. R. had been using for some years a chain brake similar to the one applied by Mr. Ambler, but had found that its use was limited to short trains and that it was not a satisfactory contrivance for the purpose intended.

There were invited to witness these trials in Philadelphia a large number of railway people and the papers gave extended notices of the tests made, which brought to the train on the next day Mr. George L. Dunlop, the General Superintendent of the Chicago & North Western Ry., who was desirous of having the whole apparatus fully explained to him. The result of his inspection of the air brake apparatus was an invitation to make a demonstration upon his railway in Chicago, and he offered, if the Pennsylvania Railroad would send a train for the purpose, to invite the leading railway people and members of the press of that vicinity. The apparatus was then transferred to a train consisting of a new locomotive and six new cars, and this train was run to Chicago over the Ft. Wayne Railroad, and a number of tests were immediately afterwards made upon the tracks of the Chicago & North Western Ry., evidently to the entire satisfaction of those present. From Chicago, the train proceeded to Indianapolis, where other tests were made, and then back to Pittsburg.

The outcome of these demonstrations was immediate orders for equipment for the Michigan Central and the Chicago & North Western, and shortly after for the Union Pacific Ry., in the West and for the Old Colony and the Boston & Providence roads in the East.

I refer to these details to illustrate the readiness with which railway officials took up this invention and the comparative ease with which the required orders were secured, and because it has been often stated that the trials and tribulations in the introduction of the brake were of the severest nature.

Works were built in Pittsburg for the manufacture of the apparatus and were fitted with the best tools obtainable. Standards were adopted and adhered to in the parts of the apparatus which required uniformity in construction in order to insure interchange of the rolling stock so fitted upon various roads. I think I am safe in saying that the course pursued in the manufacture and introduction of the brake had a more important bearing than anything else in deciding the Railway Master Mechanics and Master Car Builders a few years later to take up the question of the standardization of various parts of cars in order that repairs could be more conveniently made.

It soon developed that it took considerable time to apply the brakes with full force and a longer time to release them, and that in the event of a break-in-two of a train (a frequent occurrence in those days) the rear section would be uncontrolled, and when this occurred upon an ascending gradient, the rear detached section might run away with disastrous results. To overcome this difficulty a new development was necessary, the outcome of which was what has since been known as the automatic air brake.

In the automatic air brake equipment there were the same air-pump, reservoir, train pipe and brake cylinder, but in addition to these there were two important features added to the tender and each car equipment; the first, an auxiliary reservoir, and the second, a triple valve or device interposed between the brake pipe, brake cylinder and auxiliary reservoir whereby the train pipe and reservoir were filled with air under pressure. The valve also opened a passage from the brake cylinder to the atmosphere. This was the normal condition of the apparatus when the brakes were off.

To apply the brakes, the engineer discharged a portion of the air from the train pipe, whereupon the triple valve closed the connection between the brake pipe and the reservoir and between the brake cylinder and the atmosphere and then opened a passage from the auxiliary reservoir to the brake cylinder, the piston of which was moved outwardly by the air from the auxiliary reservoir so as to apply the brakes. The restoration of the pressure within the brake pipe released the brakes and recharged the reservoir. This development occurred during 1872 and 1873.

The automatic brake was at that time supposed to be instantaneous in its action in applying the brakes, and almost instantaneous in releasing them. In the event of the escape of air from the train pipe by its rupture or by the separation of the train, the air stored in the auxiliary reservoirs instantly and automatically applied the brakes to all parts of the train and they could only be released by either repairing the damage and restoring the pressure, or by means of special release valves operated by the train men.

The automatic brake having proved itself vastly superior to the plain or straight air brake first described, it soon became standard, but during the transition period an automatic brake was easily converted into a plain brake by a manually operated special valve arranged in the casing of the triple valve.

The gradual increase in the length of freight trains and the numerous accidents due to lack of brake control early suggested that automatic air brakes should be made a part of the equipment of all freight trains, and to determine the practicability of the automatic brake for this purpose a train of 50 cars was fitted in the early '80s and taken over the Alleghenies on the Pennsylvania Railroad, and the tests made demonstrated that such a train could be controlled on the heaviest gradients by this means.

In 1885 the Master Car Builders appointed a committee to report upon the feasibility of the application of brakes to freight trains, and this committee inaugurated what are now known as the Burlington (Ia.) brake trials made in 1886 and 1887. There were presented four test trains in all, two of them fitted with air brakes, one fitted with a vacuum brake and one with the brake operated by means of attachments to the drawbars similar to the Ambler brake first referred to. Each of these trains had 50 cars. These tests proved the inadequacy of the type of automatic air brake then presented by the Westinghouse Air Brake Company, as well as the inadequacy of all the other brakes then tested.

It became apparent that the lack of success at Burlington was due to the comparatively slow application of the brakes upon the rear portion of the train, the effect of which was to cause most serious shocks almost like collisions. A new development was imperatively needed therefore in order to insure the successful handling of freight trains of 50 or more cars.

As a part of the automatic air brake passenger equipment, I had developed in the '70s a system of train signalling involving the use of a second train pipe, which is now in general use upon all of the railways. This signaling apparatus had a sensitive valve device connected to a small reservoir upon the locomotive and these were so arranged that when compressed air was admitted through a small opening into the signalling pipe, both the pipe and reservoir were charged to a low pressure (at the present time 45 lbs.). By opening a valve at any point in the train to permit a small quantity of air to escape from the signal pipe, the delicate valve referred to was caused to move so as to admit air from its auxiliary reservoir to blow a whistle located in the cab of the locomotive. It was found upon experimentation that when the valve in any car remote from the engine was quickly opened and closed as many as five times, the whistle would be blown an equal number of times, the first time being after the last escape of air; that is to say, there were set in motion five distinct waves of air each capable of doing work.

During these developments it was found that the waves of air within the brake pipe traveled as rapidly as sound, i. e., about 1,100 ft. a sec.

Being fully impressed with the idea that if the wave of air which was utilized for signalling could be made to operate the triple valves upon the cars, there would then be an almost instantaneous application of the brakes upon the front, rear and other portions of the train, this idea, with hard work and a large number of experiments, shortly produced what is now known as the quick-action automatic brake. The Westinghouse train was left at Burlington in order that the new triple valves with the quick action attachment could be applied and further experiments made. The valves as developed for this emergency proved to be successful and the tests made with this train after their application were eminently satisfactory to the railway officials.

It was thereupon arranged to take this train to Minneapolis and St. Paul, Milwaukee, Chicago, St. Louis, Cincinnati, New York, Albany, through to Boston and New England, to Washington, and then to Pittsburg, innumerable demonstrations being made during this journey of some thousands of miles. This train, drawn by two locomotives, was frequently run at speeds above 50 miles an hour and the tests were witnessed by all of the prominent railroad people of the country.

So great was the demand for good brakes on freight trains that considerable difficulty was at first experienced in promptly filling the orders of railway companies. Nevertheless, the wide publicity given to these tests, coupled with a public demand for the adoption of means to prevent accidents, brought about the enactment of a law by the Congress obliging the railways to apply brakes and also automatic couplers to all freight trains in the United States within a time named in the Act, which time was subsequently extended because it was physically impossible for the railway companies to make the introduction within the time first prescribed.

The quick-action automatic brake was operated like the first automatic brake for ordinary train movements; the quick action resulted only when it was necessary to apply the brakes for an emergency.

No sooner had the quick-action automatic brakes been developed to operate successfully on trains of 50 cars than new conditions were presented. Steel freight cars carrying enormous loads had in the meantime been developed and freight locomotives had been increased in capacity, so that trains were often composed of 70 to 80 cars and more recently some trains have had as high as 100 cars. This possibility had, however, been foreseen and experiments were constantly being carried on to so improve the apparatus, that it could be used to control trains of any practical length, and these experiments also had in view the more nearly instantaneous action of the brakes for ordinary service purposes than was possible with the automatic brake or with the quick-action brake. The result was a most important development.

The present improved triple valve has the emergency feature, but it also has what is known as the quick-service application feature, that is, for ordinary purposes the air is admitted to all of the brake cylinders so quickly that the longest freight train can be handled with almost the precision obtainable in the control of passenger trains of from six to twelve cars.

In the matter of the development of the brakes for operation upon passenger trains, nothing that skill and perseverance could suggest has been omitted in securing the highest degree of perfection. The requirements during the past few years, by reason of the greater weight of cars and locomotives and of the higher speeds at which they are run, have necessitated the redesigning of all of the passenger train brake apparatus, including the method of attaching the brake shoes to the cars and the levers and connections for bringing these shoes to bear with the required pressure upon the wheels. For the purpose of insuring the highest efficiency, every wheel of a passenger train, including those under the locomotive, is now acted upon, whereas formerly many of the master mechanics and engineers were apprehensive that it would not be possible to make use of all of the wheels of a locomotive for braking purposes.

During the past twelve months, most elaborate tests of the latest form of apparatus for passenger service have been carried out under the direction of officials of several railways and of the Westinghouse Air Brake Co., in order to prove the operativeness of the new constructions and their capability to insure the highest degree of efficiency.

From the very beginning of its operation, the Brake Company has maintained a strong staff of experienced engineers, some of whom are located in each of the large railway centers and whose services are always at the command of the railways. It is the duty of one or more of these trained men to proceed to the scene of any accident that may have occurred in order to ascertain the cause, to report thereon and to render such aid and cooperation to the railway officials as will tend to avoid a like accident if in any manner the brake can contribute to that end.

The Air Brake Company has always had in its works, for experimental purposes, sets of brake cylinders, pipes and couplings, representing the apparatus upon trains of various lengths, so that tests and demonstrations could be readily made for all sorts of purposes, including educating or informing railway officials who same to seek information. To more effectively spread this information, the company about 15 years ago constructed and equipped a special instruction car in which were arranged 50 sets of brake cylinders and pipes equivalent to like apparatus upon a freight train. This car was provided with a boiler to drive the air-pump for the production of the air under pressure needed to operate the brakes. Operative models of all parts of the apparatus were shown in section so that their construction and operation could be more quickly comprehended. This car, in charge of experienced instructors, was moved from place to place, and engineers, firemen, conductors and other train employes in general visited it to familiarize themselves not only with the operation of the brake but with its construction, and in this manner there has been developed throughout the country a knowledge of the air brake art which has proved of inestimable value to the railway corporations and their patrons.

The records of the Westinghouse Air Brake Co. show that to Dec. 1, 1910, their instruction car had traveled over 113,000 miles. Numerous railways have also provided their own instruction cars, so that it may be safely said that every railway employe having anything to do with the operation of trains, freight or passenger, has been required to familiarize himself with the working of the brakes and to so study the subject that he could pass an examination. 280,258 employes having so far been examined by representatives of the Westinghouse Air Brake Co., and in numerous cases these men have been required to show sufficient knowledge of the brake to entitle them to receive certificates of their proficiency.

The importance of the maintenance of the brake to railways has not been overlooked by railway officials. They have appointed superintendents of brakes and numerous inspectors, and to-day there is an association of air-brake officials organized in 1893 and now having 1,015 members, who meet annually in convention to thoroughly discuss the questions which are constantly

arising, so that to-day there exists an organization of which few outside railway circles have ever heard—an organization which is constantly devoting skill and energy to the care of apparatus, which above everything else in connection with railways, contributes to the safe transportation of passengers and freight.

I have often been asked how many lives have been saved by the use of the air brake and I have as often said it might well be a great many thousand, but that it was impossible to make even an approximate estimate. At a banquet given in Washington to the members of the International Railway Congress in May, 1905, a diplomat, in speaking on the subject of the importance of railway brakes, said he felt safe in saying the air brake had saved more lives than any general had ever lost in a great battle.

I have spoken of four chief developments. It has been necessary, in order to avoid disastrous consequences, that each development should be of such a kind that cars fitted with newer apparatus could operate with little inconvenience with cars fitted with earlier apparatus. As it stands to-day, scarcely any of the old type of brake and the first type of automatic brake are in use, but should a car fitted with the first form of automatic brake be found and put into a train with the more modern apparatus, such older apparatus would be found to operate fairly well with the more perfect form. The prevailing idea in the development and introduction of the brake has therefore been an adherence to such uniformity of apparatus that the interchange of traffic over various roads could go on uninterruptedly.

There is probably no apparatus in use to-day which has received such thoughtful consideration and been the object of such care in every one of its details as what is now popularly known as the air brake, and which is in universal use in the United States and in many other countries of the world.

In my estimation, there could be no better illustration of the value of the maintenance of standards than has been given by the manufacture and introduction of air brakes upon railways, for without such standards, train brakes would not have come into general use, with consequences which railway officials and the public can well appreciate.

My story would be incomplete without a reference to the splendid assistance which the railways of this and many other countries have rendered. They have been lavish in providing those facilities for making the thousands of tests which were necessary to progress in the developments I have recited; to the Pennsylvania Railroad especially, upon which the most important experiments were first made, the other railways of the country, as well as the traveling public, owe a debt of gratitude.

Annual Meeting of the American Institute of Chemical Engineers.

The third annual meeting of the American Institute of Chemical Engineers was held in New York City, Dec. 7, 8, 9 and 10. The second and fourth days, and the afternoons of the other two days, were given up to excursions to industrial plants in the vicinity of New York City of especial interest to chemists and managers of chemical works. Among these plants visited were the Marx-Rawalle Glycerine Refinery, in Brooklyn, the Standard Oil Refining Works at Bayonne, N. J., and Blissville, L. I., and the Richmond Borough Garbage Destructor, West New Brighton, S. I. This society has now about 125 members and the average attendance at these meetings was from 30 to 40, including visitors.

At the opening session, Mr. John P. Mitchel, President of the Board of Aldermen of New York City, in welcoming the members of the Institute, announced the plans of the city for establishing and maintaining a fully equipped chemical laboratory for the examination of city supplies. This laboratory is to be governed by a board of directors made up of men of recognized high professional standing.

The officers elected and appointed at this annual meeting were as follows:

President, Dr. F. W. Frerich, Herf & Frerich Chemical Co., St. Louis; Vice-Presidents, Mr. G. P. Adamson, Baker & Adamson Chemical Co., Easton, Pa.; Mr. Eugene Haanel, Department of Mines, Ottawa, Ont., and Mr. L. H. Baekeland, Research Chemist, Yonkers, N. Y.; Secretary, Mr. J. C. Olsen, Brooklyn Polytechnic Institute; Treasurer, Mr. H. S. Renaud, Waller & Renaud, New York City.

Among the several committee reports presented was one recommending the establishment of a medal of the Institute to be awarded annually to members and non-members for the best paper on applied chemistry. A Committee on Standardizing Boiler Tests reported that it was intended that this committee should work with a similar committee from the Western Society of Engineers, but that, as such a committee had never been appointed by the latter society, no work had been done. Along with the committee reports, a resolution was adopted providing for the incorporation of the society under the laws of New York State. It was proposed to drop the name "American" from the title, but this idea was not accepted by the members present.

Aside from such business matters, the first session was devoted to the discussion of chemical engineering education, and the discussion proceeded at such length that it was carried over to the third day's session. A special committee reported the results of a canvass of the members to obtain views on the sort of course that should be given in a college or technical school so that men could be turned out ready prepared for undertaking the management of chemical works or for developing processes on a commercial and industrial scale.

Dr. F. W Atkinson, President of the Brooklyn Polytechnic Institute, presented a paper entitled "The Development of the Chemist as an Engineer," in which he stated that entirely suitable courses for the desired end were not yet found. His study of the membership cards of the Institute had revealed the fact that the members had not been trained in engineering, but that they had picked up this knowledge after leaving school. He believed that real practical ability in the works was to be acquired by a course of apprenticeship in some industry, and that this practical ability could not be acquired in college. He advised that the final report of the committee be submitted to the Society for the Promotion of Engineering Education, so that a joint meeting for the discussion of the general topic might be arranged. He also believed that a five-year course would be found necessary to give the prospective chemical engineers the foundation in chemistry, mathematics, engineering and economical principles that was demanded.

Prof. M. C. Whitaker, of Columbia University, formerly General Superintendent of Works for the Welsbach Co., in a paper entitled "The Training of Chemical Engineers Which Meets the Requirements of Manufacturers," stated that in the final analysis this training should be such that the chemical engineer could manage the works under his charge, or the processes in his care, so that profits would result on the capital invested. To this end, men must have not only the proper technical grounding, but should acquire business knowledge as well. He distinguished chemical engineers from research chemists, and stated that by the very nature of their activities there were certain differences in their training which had to be provided for in the technical schools if they were to turn out men to supply the demand at present felt. He argued that ideas of practical manipulation could be shown for one process and carried by the student to any other process.

The discussions dwelled on the different points brought up with the warning that in formulating a course for schools to give, care should be taken not to formulate an arrangement which no school could possibly hope to carry out.

At the second meeting for the discussion of papers, Dr. C. F. McKenna presented his Presidential Address, "The Evolution of Portland Cement Processes." This address was a review of the development of Portland cement processes in this country and abroad, and it was illustrated with miscellaneous lantern slides showing different plants and different pieces of apparatus. Dr. McKenna stated that it was possible to-day to mine the raw materials, grind, mix, vitrify and regrind at a cost of 1/12 ct. per lb.—an achievement of credit to mechanical engineers and chemists separately. For progress in the future, he looked to the chemical engineers to work out the problems encountered. The first process described was that covered by Aspdin's patent of 1824, in which chalk and clay were intimately mixed in wash mills, settled, dried, burned and crushed. The progress of wet process was traced. On account of the price of $5 a barrel of European cement at the close of the Civil War, the industry sprang up in this country. The first plant was in Allentown, Pa., in which argillaceous limestone and calcite were combined under Saylor's process. The use of the rotary kiln, with powdered fuel was traced. By 1895, the great difference manifest between the American and European Portland cements was in the fine grinding of the American cements compared with the coarse grinding of the European, due to the development of improved grinding machinery in this country. The final progress outlined was the reduction of fuel consumption through the use of longer rotary kilns and the recovery of the heat from clinker in cooling. It was stated that, at present, the European manufacturers were ahead of the American in many details of their work, and largely on account of their development of the wet preparation of raw materials, which, it was believed, might be adopted in this country with corresponding increase in efficiency.

Mr. R. K. Meade, of Allentown, Pa., in his paper "The Manufacture of Hydrated Lime," described the processes which were coming into use in this country for the factory slacking of burned limestone. In these processes as disclosed, the idea was to add only enough water to convert the calcium oxide into calcium hydrate. The water was added (1) in a series of cylinders, in which case the process was continuous, or (2) on a large revolving table, in which case the process was intermittent. After the calcium oxide had been hydrated so far as possible, the resultant fine powder was screened to remove small particles of vitrified matter and unslacked lime, after which the material was mechanically bagged.

In the paper, "Manufacture of Lignite Briquettes," Mr. H. S. Renaud, of Waller & Renaud, New York City, described the German processes for the preparation of lignite without the addition of binder. It was stated that some American lignites had been briquetted in Germany and that the resultant fuel had been tested on a tugboat in New York Harbor and on a Long Island R. R. locomotive with good results. The briquettes could be made and sold at $2 per ton, it was claimed, with a return of 15 to 25% on the investment.

Mr. David Wesson, Southern Cotton Oil Co., New York City, presented the paper "Bleaching Oils with Fuller's Earth." In this he attributed the discovery of the oil-bleaching properties of Fuller's earth (clay containing enough fine silicious matter to destroy its plasticity) to a description given the N. K. Fairbanks Company in 1878 of the custom of clarifying olive oil in Turkey by agitating with clay. He described the processes in general use and the precautions necessary in some cases to prevent spontaneous combustion of the "spent" earth after its removal from the oil.

Mr. Jerome Alexander, of the National Gum and Mica Co., New York City, in "The Fitzgibbons Boiler" described a novel combination of horizontal and vertical features, originated for marine use but adapted to stationary plants. The furnace, as shown, is near the bottom of a vertical sylinder and is surrounded by a water leg. Above this and close to the fire door is an unlined combustion chamber, the partially burned gases combining there with air admitted through the fire doors. From this chamber, fire tubes lead through the horizontal extension to the uptake. The feed water is admitted to the extension where the flue gases are coolest and the stream is mostly generated in the cylindrical parts. It was claimed that this boiler was a quicker steamer even than any water-tube type, needed only 40% the floor space of an ordinary tubular boiler for a given capacity, cost about the same as a tubular boiler in place, and under ordinary good conditions maintained an efficiency of 80%.

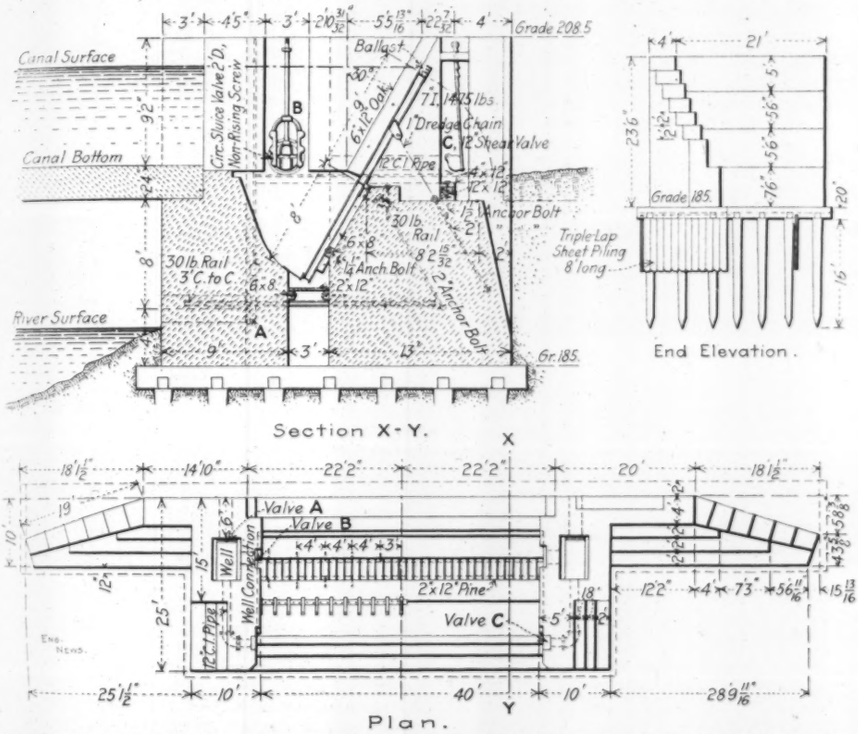
The final session, on the evening of Dec. 9 at the Chemists Club, was held jointly with the New York section of The American Chemical

Society. The general subject considered was "Sewage Disposal" and the following program was offered:

"Principles of Sewage Disposal," Mr. Geo. C. Whipple, of Hazen & Whipple, New York City; "Sewage Disposal in Europe," Mr. Rudolph Hering, of Hering & Fuller, New York City; "Sewage Disposal in New York and Vicinity," Dr. G. A. Soper, Metropolitan Sewage Commission, New York City; "Sanitary Conditions in Their Relation to Water Supplies in the Vicinity of New York," Mr. Nicholas S. Hill, Jr., Consulting Engineer, New York City; "Unsolved Problems of Sewage Disposal," Prof. C.-E. A. Winslow, College of The City of New York.

Emergency Gates on the Illinois and Mississippi Canal.

In the "Professional Memoirs, Corps of Engineers, U. S. Army, and Engineer Department at Large" for July-September, 1910, Maj. C. S. Riché, Corps of Engineers, U. S. A., describes some emergency gates which have been built on the so-called Hennepin Canal, officially known as the Illinois & Mississippi Canal. From that article we have prepared the following description of the more important of the gates, the one designed, in duplicate, to retain water in the summit level, in case of serious break or crevasse in the canal banks.



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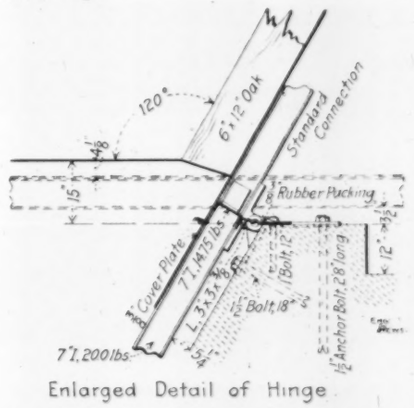


Enlarged Detail of Hinge

End Elevation.

DETAILS OF EMERGENCY CLOSING GATE ON THE SUMMIT LEVEL OF THE ILLINOIS AND MISSISSIPPI CANAL.

This canal connects the upper Illinois River, near Hennepin, with the upper Mississippi at the mouth of Rock River, just below Rock Island, Ill. In its total length of 75 miles, in 18 miles it rises 196 ft. from the east, and in 46 miles rises 93 ft. from the west, leaving a summit level of 11 miles. This summit is supplied with water from a feeder 29.3 miles long, so that the combined feeder and level comprise 40.3 miles of unbroken canal with a maximum content of some 100,000,000 cu. ft. of water. In order to prevent the escape of all of this water in case of a break anywhere along the 40.3-mile length, it was some years ago decided necessary to build lock gates, which could be closed quickly in an emergency and hold most of the water in the canal.

The best location for such gates proved to be on the feeder about 23 miles below its head and 6.3 miles above the entrance into the canal. At this point the feeder crosses over a small stream known as Green River on an aqueduct, the abutments to which made an excellent foundation for the gates. Two similar gates were built here, one at each end of the aqueduct.

The design of the gate, a simple form of the Des Fontaines type of weir, is shown in the accompanying figure. It will be seen from the figure that the wing abutments which hold the aqueduct across the river have been utilized as the basis of the gate. In brief it is a hinged gate normally lying flat in the canal bottom in the abutment, and when acting as a dam swinging down into a trench provided for that purpose. It is normally operated by varying the water-pressure in the trench, as described below, but under certain conditions of extreme flow its operation is automatic.

The gate is formed by a series of parallel 7-in. I-beams, each of which is hinged to the supporting masonry, close to its middle point, and all of which are connected by a ⅜-in. steel plate, to which they are riveted. The hinges are on the lower part of the beams, close to the median line of the gate. Under the lower of the two parts into which the hinges divide the gate is the trench into which the gate swings. This is 3 ft. wide and extends as an open trench entirely across the 40-ft. width of the canal, and as a tunnel into the operating well on the side walls on either side of the canal.

The lower part of the gate that swings down into the trench does not fit the masonry closely at its swinging edge, but this edge is provided with a hinged mud guard or flap that keeps contact with the masonry as the gate swings. The part of the gate on the opposite side of the hinges from the trench is somewhat the larger and heavier, and provision is made for adding weight in the shape of railroad iron, etc., to ensure proper operation.

When the water in the trench or chamber under the gate is at the same head as the water in the canal above the gate, the preponderance of weight in the heavier part will keep it lying flat upon the bottom of the aqueduct. When, by the proper manipulation of the valves, the water in the trench under the gate is allowed to run out into the river below, the pressure on the part of the gate over this trench forces this part down and so raises the other part and dams the canal. By the reverse manipulation of valves water is admitted from the canal into the trench and the gate slowly drops to its horizontal position by the action of gravity.

The operation of these valves is as follows: Normally, the gate is flat in the canal and the trench and operating well are full of water. If a break occurs anywhere on the level, valve A is opened, thus drawing water out of the well and, through the connecting tunnel, from the trench into the river, creating a head on the lower end of the gate and turning it to the closing position. When it is again desired to release the dam, valve A is shut off, valve B or C, depending upon the location of the water, is opened and the trench again fills and the dam turns down to the horizontal position.

In regard to the number and operation of the gates, Maj. Riché, in his article, says:

It was intended that the gate should be so operated that it would rise *against* any current that might develop in the canal, in order that it might come into position gently and without shock, and so avoid danger of being carried away, as was feared might be the case were it to be raised *with* the current.

Two gates were therefore provided, one at each end of the aqueduct; the one at the south end to be operated against the southerly current that would be caused by a crevasse south of the aqueduct, and the other at the north end to be operated against a northerly current that would be caused by a crevasse north of the aqueduct. But as one of the gates might, either accidentally or purposely, be operated in the reverse direction, and have to rise with the current instead of against it, additional precautions against its being carried away were taken by providing chains connecting each I-beam in the heavier part of the gate to an anchor in the masonry below. The gates rising with the current would thus be stopped and held by these chains and by the central hinges.

At each side of the aqueduct the gate works with a clearance of approximately 1 in. between itself and the masonry, and when raised presses against a wooden cushion, forming a nearly tight dam across the canal.

After these gates had been installed and the canal filled with water, there was no opportunity to test them for the emergency use for which they were intended. They could be raised and lowered as desired in the comparatively still water of the canal. How they would operate in the fact of a strong current remained to be seen. The test finally came after the gates had been in place and under water for about a year and a half. During the night of May 16-17, 1900, a crevasse occurred immediately at the southeast corner of the aqueduct.

It is thought that this crevasse started about 3 a. m. The alarm was given about 5 a. m., and the overseer, who lived about a quarter mile from the aqueduct, hurried to it and found that the gate at the *north* end of the aqueduct had been automatically raised by the current and was holding in the canal all water north of the aqueduct.

The crevasse was repaired in due course, and water had again been admitted to all parts of the canal when a second crevasse occurred at the same spot, the southeast corner of the aqueduct.

This time it was daylight, and Overseer W. H. Murphy happened to be present. What occurred can best be told in his own words:

About 7 p. m. I examined the river bed near the south abutment and saw nothing unusual. At 7.45 p. m., the exact time of the break, I was standing with the night watchman on a sand bar a few feet east of the east end of the north pier, about 140 ft. from the southeast corner of the aqueduct, looking toward the spot where the break occurred. At first, a stream of black water about 10 ins. in diameter and 18 ins. high shot up at a point about 8 ft. east and 10 ft. north of the northeast corner of the south abutment.

We ran immediately to the southeast corner of the aqueduct to close the south emergency gate. By the time we got there the water was running very swiftly over the gate and the gate would not close when the valve was opened. We then ran to the north gate and closed it. The north gate closed easily and quickly, but without any shock.

While trying to close the south gate I saw about 25 ft. of the crib over the break go out. Part of the stone in the crib fell through and the timbers in the crib broke.

The crib was carried about 200 ft. to the north side of the river and the stone was scattered all the way across.

The upper part of the east embankment south of the aqueduct held until after we closed the north emergency gate, the water having made a tunnel at the bot-

tom. The first of the top fell in about 12 or 14 ft. south of the masonry, leaving the bank projecting about 3 ft.

The crevasse occurring right at the south end of the aqueduct caused a practically torrential flow of water over the south gate. The current was too strong and the gate could not be raised against it. Had the crevasse been half a mile or more southward, it is probable that the current caused by it would not have been so strong as to prevent the gate's operation. But this yet remains to be seen. There was no doubt, however, as to the north gate. It operated promptly, rising with the current and coming into place without shock, probably by reason of the cushioning effect of the water in the trench beneath it.

That this gate would have operated automatically is known, because it did so operate at the time of the first crevasse. How soon it would have thus operated is not known; the overseer naturally did not wait to find out.

In the case of these two crevasses these gates have paid for themselves many times over in reducing the damage that would otherwise have occurred. In addition, they preserved a line of communication, enabling the crevasse to be reached by water from the north, and thus effecting a material saving in assembling repair material at the locality.

The design adopted for the gates was suggested by Mr. Chas. Holth, the engineer in charge of the designing work in the headquarters office in Chicago and the detailed design was made by Mr. Fred W. Honens under the immediate supervision of Ass't Engineer L. L. Wheeler. Maj. Riché was in charge of the works connected with the canal.

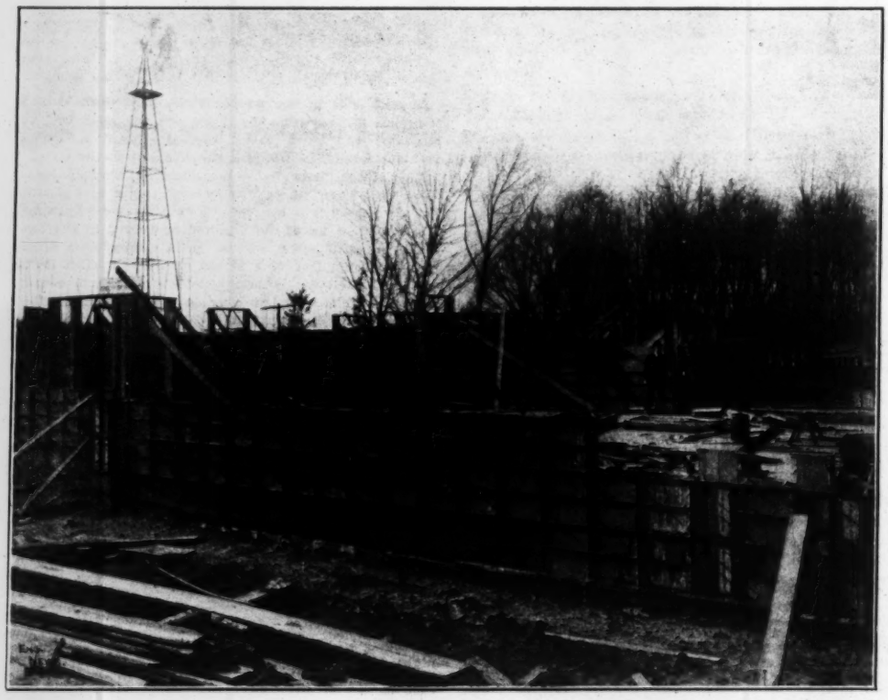
Steel Forms for Monolithic Concrete Buildings.

In connection with the construction of its new plant at Gary, Ind., the American Sheet & Tin Plate Co. will erect about 200 dwelling houses for its workmen. These buildings will be of monolithic concrete construction, and will be built in steel forms of the patented type manufactured by the Reichert Mfg. Co., of Milwaukee, Wis. Owing to the large number of forms required, and the demand for their immediate use, this company has authorized the tin-plate company to have these for its own use made by an outside shop, and this work has been given to the American Bridge Co.

The Reichert metal forms consist of 24-in. panels No. 16 galvanized steel plate, with edges of 1 × 1-in. angles on the outer side. Each panel has a lock for fastening it to the adjacent panel or to the corner connections. The opposite panels of the inner and outer forms are held together by wire ties, and at the top of the form they are held together by transverse stay rods hooked over the flanges. These forms have been used for a number of buildings in Milwaukee during the past five years, and those first used are said to be still in good condition. Their use reduces the time of construction materially, owing to the saving in time for making and erecting wooden forms. Cores may be placed to make hollow walls, flues, etc. Interior strips may be fitted to give a block appearance to the wall, with beveled grooves. Door and window frames are set in place in the forms. The accompanying cut shows the commencement of work on a building, with four rows of panels in place. At pilasters, corners, etc., the panels may be placed vertically, as shown. The view shows also (at the right) the use of special panels to conform to the dimensions and design of the building.

We are informed that for the work at Gary there will be a supply of forms sufficient for 12 buildings, and these will be set up first for the foundations, basement walls, basement partitions and first floor slab. A portable concrete mixing and hoisting plant will run on a track parallel with the row of buildings, and the entire amount of concrete for the foundations, basement and floor slab will be poured at one operation. As this work is completed at each building the machine will move on to the next one. By the time this has been done for the entire row of buildings, the concrete of the first buildings will have set, so that the forms will have been removed and re-erected for the first story walls and partitions, etc. The machine, therefore, will be run back to the head of the line and proceed to pour the concrete for the first story and the second floor. A third trip will complete the pouring for the second story and roof. It is expected that the cost of the buildings will be somewhat less than that of frame structures, owing to the very small amount of labor and skilled work required. It is stated also that even if the cost should be 12 to 20% more than that for a frame building, this would be balanced by the saving in cost of repairing and repainting and by the reduced insurance rates.

These steel forms are being used also for two-story factory buildings of identical design which are being built by the Stone & Webster Engineering Co. at Berlin, Wis., and Richland Center, Wis., for the Pacific Coast Condensed Milk Co., of Seattle, Wash. It is stated that work was started so late that if wooden forms had been used the buildings could not have been finished before the end of the year. Investigation showed that with the steel forms the work could be completed in much less time and at less cost, as the forms will be used for several buildings. These buildings will have walls 11 ins. thick to about 4 ft. above ground, then 9 ins. to the second floor and then 6 ins. to the top. The walls will be reinforced at frequent intervals by pilasters 6 ins. thick and 24 ins. wide.



STEEL PANEL FORMS IN PLACE FOR THE CONSTRUCTION OF A REINFORCED-CONCRETE BUILDING.

(Reichert Mfg. Co., Milwaukee, Wis.; Makers.)

Annual Meeting of the American Society of Mechanical Engineers.

The 31st annual meeting of the American Society of Mechanical Engineers was held last week at the Engineering Societies Building in New York City. At the opening session on Tuesday evening, Dec. 6, the retiring president, Mr. George Westinghouse, made an address in which he outlined most interestingly the successive steps in the invention and development of the modern railway air-brake. An abstract of this paper is published elsewhere in this issue. The result of the ballot for election of new officers was then announced as follows: President, Col. E. D. Meier, of New York City. Vice-Presidents, H. H. Vaughan, of Montreal; E. M. Herr, of Pittsburg, and Geo. M. Brill, of Chicago. Managers, D. F. Cramford, of Pittsburg; E. B. Katte, of New York City, and Stanley G. Flagg, of Philadelphia. Treasurer, Hon. Wm. H. Wiley, of New York City.

The Wednesday morning session, at which Col. Meier presided, was mainly a business session but time was made for the presentation of a paper on "The Transmission of Heat in Surface Condensation," by Mr. George A. Orrok, of the New York Edison Co.

In response to the call for new business, Prof. Edward Robinson of the University of Vermont, brought up the question of the establishment in this country of an engineering and industrial museum similar to the one at Munich, Bavaria. It was suggested that contributions could be made toward a fund for this purpose and allowed to accumulate until enough was available. Secretary Calvin W. Rice announced that there was a room on the twelfth floor of the Engineering Societies Building available for use as a museum, but those most interested seemed to scorn such limited quarters. No definite action on this question was taken.

A suggestion that the Society establish a bureau for the collection of data of engineering tests brought out the announcement by Prof. Charles E. Lucke, of Columbia University, that the Meetings Committee, in whose hands this matter had already been placed, had recommended the appointment of a special committee to consider this and other related questions. Resolutions were adopted expressing a sense of loss in the recent sudden death of Wm. H. Bryan, of St. Louis. (Mr. Bryan's death was noted in Eng. News, Dec. 8).

Honorary Secretary F. R. Hutton, of New York City, read an interesting report of what he called the "inner happenings" of the joint meeting in England last summer.

Steam Engineering.

Mr. Orrok's paper on "The Transmission of Heat in Surface Condensation," presented the results of an extensive series of tests made by the author at one of the power stations of the New York Edison Co. Mr. Orrok had made a study of all other available experiments on the subject, reduced them to a common basis and compared them. From this he was able to deduce a statement of the law of heat transmission in condenser practice taking into account the effect of temperature difference, cooling water velocity, air leakage and the tube material. So careful an investigation, he explained, was, perhaps, unnecessary in the days of small condenser capacities, but now that the development of the steam turbine demands condenser capaci-

ties of more than 200,000 lbs. steam per hour at a pressure of less than 1 lb. absolute, the high first cost and upkeep prohibits the old plan of installing excessive amounts of surface.

High commendation of Mr. Orrok's paper was the dominant tone of the discussion. Prof. Wm. D. Ennis, of Brooklyn Polytechnic Institute, however, called attention to the irregularity of the points from which were plotted the curves of variation of heat transmission with water velocity. He had some misgivings that these irregularities might be due to some other cause than inleakage of air (the explanation given by Mr. Orrok). Mr. Wm. Kent, of Montclair, N. J., objected to this method of computing the mean temperature difference of the steam and cooling water. Mr. Orrok had used the geometrical mean and Mr. Kent objected that this did not truly represent the conditions of temperature variation. Mr. Orrok explained that he knew of no definite law for variation of temperature difference in condensers and had used the geometrical mean on account of the convenience of computation and because it probably differed but slightly from the true mean.

Mr. Thomas C. McBride, of Philadelphia, Pa., who presented a paper on the effect of air leakage in surface condensers at the June, 1908, meeting in Detroit, questioned the accuracy of Mr. Orrok's estimate of the partial air pressure in his test condenser apparatus. Mr. Orrok had estimated that the partial air pressure "never exceeded ¼-in. of mercury," and Mr. McBride considered that it must have been very much less than that. His opinion was based on the excessive vacuum pump capacity that such an air pressure would necessitate.

Mr. Orrok appeared to be unshaken in his estimate of ¼-in. maximum air pressure by Mr. McBride's criticism. He explained that the exhaust steam used in the tests was taken from a header receiving the exhaust from large blower engines and other units, and that there were many chances for leakage into the header and the pipe connections to the test condenser tube.

In response to questions raised by Prof. Ennis, Mr. Orrok explained that he was unable to detect any difference in the results with 16, 18 and 20-gage tubes. Most of the tests, therefore, were made with tubes of 18-gage thickness. The tubes were never used up to the limit of their capacity and all the operating conditions were kept within those found in ordinary condenser practice.

Steam engineering was the general subject of the papers presented at the Wednesday afternoon session, at which Prof. R. C. Carpenter, of Cornell University, presided. The first paper, presented by Mr. Edward A. Uehling, of Passaic, N. J., was entitled "Combustion and Boiler Efficiency." It was set forth in this paper that the controlling factors in the production of furnace and boiler efficiency are the slack temperature and the percentage of CO_2 in the flue gases. It was lamentable, the author said, that a more general use was not made of automatic CO_2 recorders and recording thermometers for slack temperature.

In the discussion, it was generally conceded that under normal operation the amount of CO_2 in the slack gas was a good index of boiler efficiency. General dissatisfaction was expressed, however, in regard to the forms of automatic CO_2 recorders now on the market, and it was objected, too, that the practical value of even a perfect recorder would be largely dependent on the honesty of the fireman. It was stated that dishonest or lazy firemen soon found means of manipulating their fires so as to get high CO_2 records while operating their furnaces uneconomically.

Prof. Ennis gave an interesting report of some of his experience in the use of automatic recorders and other means of analyzing slack gases. He maintained that the indication made by the automatic machines was not continuous in the sense of being a measure of the existing condition in the furnace. This was due largely to the length of small piping between boiler and instrument. By the use of special instruments, he had found that the gas samples took from five to six minutes to pass from the boiler to the machine and about 17 minutes to go through the machine after they reached it. His firemen complained that the recorder showed the poorest records at the time when they had the fire in the best condition. Prof. Ennis' experience, however, had shown to his satisfaction that a high percentage of CO_2 in the flue gas went hand-in-hand with good boiler efficiency. As the percentage of CO_2 became higher, however, the proportionate gain in efficiency from further increase of CO_2 diminished. An increase of CO_2 from 4% to 5% meant a gain in efficiency several times as large as that obtained by increasing the CO_2 from 11% to 12%.

He had experienced some difficulty in getting correct analyses due to absorption of CO_2 by the water over which it was collected. This was when continuous samples of flue gas were collected in a large reservoir ready for subsequent analysis. The salt and water solution recommended by automatic recorder makers had proved as bad as the water in this respect. Satisfactory results were at last obtained by covering the water with a film of kerosene oil.

Mr. Wm. Kent pointed out in his discussion the importance of furnace temperature as an index of economy of operation. A furnace temperature of 3,000° F. indicated a good economy while a temperature as low as 1,500° F. in the furnace showed poor combustion. He remarked incidentally that too much attention was frequently given to determining the calorific value of the coal burned. In the case of semi-bituminous and anthracite coals, it would probably be nearer the truth to take the calorific power at the well-established average value for the given coal than to send samples to a chemist for a calorimeter test. This did not apply to bituminous coals, as coal from the same mine would vary widely in heating value. A determination of moisture and ash was always important as these constituents varied widely and had a considerable influence on the furnace economy. Dry coal, he said, was essential to secure the best economy.

The paper on "Automatic Control of Condensing Water," by Mr. B. Viola, of Brooklyn, N. Y., dealt only with condensers for vacuum pans such as are used in sugar refining and other industries. A device was described for automatically regulating the amount of cooling water admitted to the condenser, so as to keep the temperature of the outlet water at the point corresponding with maximum economy. Differential expansion of a brass tube and enclosed rod made of a special alloy was utilized to operate a valve controlling the admission of compressed air to a diaphram operating the cooling water supply valve. Mr. Geo. Dinkel, Consulting Engineer of the American Sugar Refining Co., New York City, in his discussion of Mr. Viola's paper, criticized it rather severely, saying the condensers described were out of date. The opinion was advanced also that the regulation secured with Mr. Viola's device was not close enough to justify its use, and various possible improvements were suggested.

Of the two papers on steam turbine tests, the first was entitled "Test of a 10,000-KW. Steam Turbine," and gave the results of the acceptance test on a turbine-generator unit installed in the main power station of the City Electric Co., San Francisco, Cal. In the absence of the author, Mr. Sam L. Naphtaly, General Superintendent of the City Electric Co., the paper was presented by Mr. A. W. K. Billings, of New York City. The B. T. U. per KW.-hr. ranged from 15,062 to 18,587, and the thermal efficiency from 18.35 to 22.65%. The lowest steam consumption was 13.88 lbs. per KW.-hr. The turbine was of the double-flow type and had both impulse and reaction elements. The generator was of the most recent four-pole construction and showed an efficiency on full load of 97.6%. Several of those who discussed this paper called attention to the fact that the final results did not seem to correspond with the observed data. This was supposedly due to the omission of some of the recorded data affecting the results. It was thought desirable that the complete log of such tests be included in reports submitted to the society.

The second turbine paper, "Test of a 9,000-KW. Turbo-Generator Set," by F. H. Varney, of San Francisco, Cal., gave results of a test made on such a unit in the municipal power station of the City of Oakland, Cal. The plant had been in operation 14 months before the test was made. The turbine was of the multi-stage Curtis type. The water rates per KW.-hr. in the two runs made were 15.42 lbs. and 15.82 lbs. In the discussion, Mr. I. E. Moultrop, of Boston, Mass., called attention to the very low cost given in Mr. Varney's paper, which was only $51 per KW. for the entire plant excepting land. Mr. Moultrop considered that the turbine had made a rather poor showing. He mentioned a 4,500-KW Curtis turbine which had shown a water rate of 13.64 lbs. per KW.-hr., and a 5,000-KW. Curtis turbine at the Boston Edison plant which showed a water rate of 12.71 lbs. per KW.-hr. Mr. Orrok presented a table he had compiled showing the comparative performance under test of a number of notable turbine installations.

"Notes on the Value of Napier's Coefficient With Superheated Steam," by Isaac Harter, Jr., of Bayonne, N. J., showed values of C, in the formula $W = \frac{a\,p}{C}$ for flow of steam through an orifice, ranging from about 72.5 to nearly 80 with superheats of from 10° to 180° F. Unfortunately, the orifice used was not of standard shape. The author concluded that while no quantitative results could be obtained from his data as to the effect of superheat on the flow of steam in piping, the test showed that there was need for investigation and probable revision of the frequent assumption that smaller pipe sizes can be used with superheated steam for the transfer of a given amount of energy with a given pressure drop.

Written discussions were submitted by Mr. Henry E. Longwell, of Pittsburg, Pa., and by Professor Robert Heck, of Rutgers College, New Brunswick, N. J.

Machine Design and Construction.

At the Thursday morning session, four papers were presented dealing respectively with belt driving, connecting-rod design, elevator operation and shoemaking machinery. The paper on "A New Theory of Belt Driving," by Selby Haar, of Schenectady, N. Y., summarized the conclusions derived from an investigation of the results of tests of belting made by a number of experimenters. The tests to which most attention was paid in the paper were those of C. Otis Gehrckens and those of Prof. Kammerer, of Charlottenberg. The general trend of the paper was to favor the operation of leather belts at higher speeds than those of common practice. Among the ideas advanced to support this were those that the maximum allowable tension in a belt increased with the speed, that the coefficient of friction increased with the speed, and that the maximum efficiency of transmission is not limited by the speed.

A favorable written discussion of Mr. Haar's paper had been submitted by Mr. A. F. Nagle, of Bethlehem, Pa., who commended in particular the curves showing safe loads on belts. Mr. Haar had plotted these curves from data given in a paper by Mr. Gehrckens. Mr. W. L. R. Emmet, of Schenectady, N. Y., considered these same "safe load" curves to be incorrect and misleading, as the loads shown were too high. High tension in belts, he said, resulted in stretch, slip and wear.

Mr. Frederick W. Taylor, of Philadelphia, Pa., criticized severely the conclusions given in the paper. Experiments on belting, in Mr. Taylor's opinion, were of no practical value unless continued over a much longer period than those cited by Mr. Haar. Mr. Taylor strongly opposed high speed for leather belts. He had found that belts operated at 5,000 to 6,000 ft. per min., which was about half the speed mentioned by Mr. Haar as allowable, stretched excessively in actual service. The maximum possible efficiency was not what was wanted in leather belting. The thing to strive for was the best all around economy. Mr. Taylor had found that the biggest item of expense in connection with belting was not the first cost nor the power lost in transmission but the interruption to manufacture due to belt fail-

ures. He considered speeds as high as 5,000 ft. per min. to be ruinous to belting and not to be allowed unless necessitated by circumstances. Mr. Taylor desired to warn younger engineers from being misled by Mr. Haar's paper.

"A Graphical Method for Calculating Stresses in a Connecting Rod" was the title of the next paper, which was presented by the author, Winslow H. Herschel, of New York City. The method given in this paper was rather tedious compared with ordinary methods by the more or less empirical formulas. Mr. Herschel explained that his method was intended especially for tapering rods and that its usefulness would lie in ascertaining the general proportions for one rod of each type, not for designing each separate rod.

Mr. R. P. Bolton, of New York City, presented a paper on "Operating Conditions of Passenger Elevators." The main point dwelt on in this paper was the value of observation of the number of passengers carried by elevators at each hour of the day. The author gave the records of such observations for several different office buildings and explained in a general way how this data could be used to advantage in elevator design.

A paper on "Modern Shoe Manufacture," by M. B. Kaven and J. B. Hadaway, of Beverly, Mass., was presented by Mr. J. B. Hadaway. After explaining the construction of hand-sewed shoes and the Goodyear welt shoe, this paper entered upon a description of a modern shoe factory. The process of making a shoe was followed through from the cutting of the skins to the final inspection and packing. The paper concluded with a detailed description of the operation of the welt-sewing machine.

In discussion of Mr. Hadaway's paper, Mr. I. E. Moultrop read a letter from Mr. R. H. Long, an independent shoe manufacturer, who claimed that but little progress had been made in recent years in the development of shoe machinery because of the monopoly maintained by the United Shoe Machinery Co. In refutation of this charge, Mr. Hadaway, who is an official of the company named, declared that no less than 20 new machines had been brought out by his company in the past year and that some 300 projects for improved design were now under consideration. He stated that in a modern shoe factory a total of 600 employees, including office help, can produce 3,000 pairs of shoes per day—an average of 5 pairs per day per employee.

Machine Shop Practice.

On Thursday afternoon two simultaneous sessions were held, one for the gas-power section and the other for papers on machine-shop practice. The three machine-shop papers all dealt with modern practice in grinding and were presented together, in succession, before any were submitted for discussion. "The Field for Grinding," by C. H. Norton, of Worcester, Mass., explained that the ordinary conception of grinding as a synonym for slowness and drudgery was not at all applicable to the modern grinding machine. The improved grinding wheels now in use acted like milling cutters with a multitude of small cutting points. The microscope revealed that such wheels cut off chips resembling those from a lathe, instead of grinding off powder as did the old emery wheels. The grinding machine gave diameters to such small limits as to be called exact, but at the same time, no one should lose sight of the fact that for many classes of work the maximum economy was to be obtained by rough turning in a lathe and finishing on the grinding machine. Mr. Norton's paper concluded with descriptions of a number of specific jobs performed on the grinding machine. Most of these were on automobile parts.

Mr. W. A. Viall, of Providence, R. I., presented a paper on "Precision Grinding." It was pointed out in this paper that grinding was an art in which no exact rules could be layed down to cover all kinds of work. Much depended of necessity on the judgment and experience of the operator. Tables were given of the limits adopted by the Browne & Sharpe Manufacturing Co. for grinding cylindrical pieces for various fits. A table was also given of the limit-gage sizes for lathe work to be finished in the grinding machine. A number of drawings of small machine parts, mostly for sewing machines, were accompanied by a table of wheels and speeds used for each piece and of the number of pieces handled per hour.

The third paper was entitled "Modern Grinding Methods," by B. M. W. Hanson, of Hartford, Conn. Mr. Hanson's paper described an automatic electrical device for controlling the feed on a cylindrical grinding machine. A coarse feed was used until nearly to size, whereupon the automatic device changed the feed to a finer one. The fine feed was in turn automatically thrown out when the piece had been ground to size. Surface grinding machines were briefly described and many examples shown by illustration of surface grinding done with a cupped-wheel machine. Among the lantern slides shown by Mr. Hanson was one of an anvil which had been resurfaced by the grinding machine after it had become so rough as to be ready for the scrap heap.

The discussion opened with a number of written contributions whose general tone indicated that the writers believed the prospects for the general adoption of the grinding machine for all finishing cuts were not so immediate as the three papers seemed to suggest. No definite information was available to guide the choice of wheels, feeds, speeds, etc. The selection of the proper wheel for a given piece of work must take into account the quality of the abrasive material, the tenacity of the binding material holding the wheel together and the coarseness of grain of the abrasive. It was pointed out that the amount of vibration to which the wheel would be subjected was a factor in determining the strength of bond required.

Mr. Henry Hess, of Philadelphia, Pa., pointed out that the grinding machine could handle a wider range of work without change of cutting tool than any other used in the machine shop. He considered the limits given in Mr. Viall's table as rather too modest, as he had experienced no difficulty in working to a limit of 0.0002 of an inch on cylindrical work with ordinary day labor. The user of the grinding machine should expect to develop his own methods of handling work and determine for himself the best conditions of operation, just as he would with any other machine tool.

Mr. H. M. Leland, of Detroit, Mich., paid a graceful tribute to Joseph R. Browne, the inventor of the universal grinding machine. It was later explained by Mr. Viall that the first universal grinder was built for the manufacture of sewing-machine shafts.

Mr. Norton, in closing the discussion, corrected the notion that coarse wheels necessarily cut rough surfaces. A wheel with coarse grains and a hard bond could be used to cut a mirror surface, but more power would be required than with a finer grained wheel. He mentioned some large bridge pins (6 ft. long by about 12 ins. in diameter) which it was found could be finished more economically on a grinder than on a lathe. On such large work the lathe tool would show appreciable wear during a single cut. Referring to a statement in Mr. Hanson's paper that the cupped-wheel surface grinder was more rapid than the planer type of grinder, Mr. Norton stated that the peripheral cutting wheel was best for removing large amounts of material—a heavier cut could be taken than with the cupped wheel. The cupped wheel was better for such work as surfacing the bosses of adding-machine frames than for continuous surfaces.

The speed of the grinding wheel relative to the work, Mr. Norton said, was not of as much importance as was often believed. In his own practice, the proportioning of speed and feed was left largely to the operators. The alundum wheel was commonly used at a speed of about 6,000 ft. per minute. One of those who took part in the discussion had upheld the use of square centers in grinding machine work as a time-saving substitute for dogging; and another had declared that grinding machines should be used only for light cuts, to avoid springing and heating the work. Mr. Norton said that only light cuts could be taken with square centers and that time could be saved by dogging and taking heavier cuts. He referred to the use of improved forms of steady-rest as an important development in grinding machine practice.

Gas Power Section.

The Gas Power Section of the Society held a well attended session on Thursday afternoon opening with an address by the retiring Chairman of the Section, Mr. J. R. Bibbins, which we shall publish next week. The principal paper of the session was by Mr. E. P. Coleman, whose sudden death occurred at Buffalo just prior to the meeting. His paper described the blast furnace gas engines at the Lackawanna steel works in Buffalo. These are two-cycle Koerting engines and were the first large gas engines using blast furnace gas, to be built in this country. The difficulties experienced in their installation and operation were fully described in the paper and made it of great interest. It was discussed until a late hour, so that comparatively little time was left for the second paper in the program. This, however, was a paper of much less importance. It was by Mr. Nisbet Latta, of Milwaukee, Wis., and described a test of a gas producer using powdered coal. From the paper and discussion it was evident that the producer was a failure both technically and commercially.

The election of officers of the Section for the ensuing year resulted in the choice of Mr. Robert H. Fernald as Chairman, and Messrs. C. J. Davidson, E. D. Dreyfus and Francis H. Stillman as Members of the Executive Committee.

Notes from Engineering Schools.

UNIVERSITY OF ARIZONA.—Beginning with the second semester of the present school year, the Department of Civil Engineering will offer nearly all of the junior and senior courses in civil engineering on a consultation basis. The members of each class will not meet in a body for recitations, but each student will be assigned one or two consultation periods per week, for conference with his instructor. There may be a few lecture periods, in addition to the consultations, for which the class will be required to meet as a whole. Since there are ordinarily but a few students in each of the junior and senior courses, it is thought that the consultation method will not involve a large amount of additional work for the department. The work which will be required for the prescribed credit in each course will be determined in advance, and no student will be given credit in a subject until he has completed all of the prescribed work. On the other hand a student will be allowed to complete his work as rapidly as he may be able. One of the advantages which is anticipated from this plan is that students who have not been in attendance at the University during the preceding semester can be assigned work for which they are prepared.

MUNICIPAL SUBWAY EXTENSION IN BERLIN was undertaken two years ago by the suburb Schöneberg, and on Dec. 1, 1910, the line was opened to traffic. It connects with the Elevated & Underground Ry. at Nollendorfplatz, and extends thence southerly a little less than 2 miles (2,993 m.), mainly as two-track line. The subway, 20½ ft. wide in the clear and 10.8 ft. high in the clear above top of rail, consists of concrete floor with steel wall columns and roof beams 5½ ft. apart carrying concrete filling, all waterproofed below groundwater with three layers of asphalt fabric and above groundwater with two layers. There are three stations between terminals. The line extends partly through undeveloped territory, and therefore no private undertakers were willing to build it. The municipal authorities on Sept. 7, 1908, authorized construction by city funds, and work began the following day. The cost for construction and equipment was estimated at $3,475,000, which will not be exceeded by the final settlement. Siemens & Halske were the contractors, under unit-price contract. The line is capable of extension both north and south. The crossing with the Hoch und Untergrund bahn is not at grade, and a large traffic interchange station will ultimately be built there in place of the present terminal station.—(Zentralblatt der Bauverwaltung, Nov. 30, 1910.)

The New Filtration Plant at Portsmouth, England.

As an addition to the water-supply of the Borough of Portsmouth, England, there has recently been constructed a series of filter beds and reservoirs, which, while not being distinctly novel in general design, are so economically located as to be worth description. The works are described in a recent issue of "London Engineering." From that issue we have abstracted the following account.

The water-supply of the borough is pumped from adjacent chalk springs through three mains 20, 24 and 36 ins., respectively, and has up to recently been delivered to the houses after receiving only the purification which it could get in two sedimentation reservoirs. On account of the discoloration which occurs in wet weather after a period of drought, it was decided to install slow sand filters between the springs and the reservoirs, and to build two new reservoirs to take care of the filtered water. As a part of the new work, covers were added to the old reservoirs. As shown in Fig. 1, the old reservoirs were located on the side of a hill, partly in fill and partly in cut, and the new works were placed immediately alongside. This necessitated the upper end of the filters being put into the side hill and required that their lower end be some distance above the surface of the ground. In order to economize space, it was decided to place the new reservoirs partly under the filter beds, as shown in Fig. 2. This not only reduced the area required for the total plant, but also materially reduced the amount of excavation and fill necessary.

Fig. 2 shows a section through the plant from the high point or upper end of the filter to the low point or lower end of the new reservoir. It will be seen that the north ends of both the filter beds and of the new reservoirs are formed in the steps cut out of the hill-side, which is of solid chalk. At the north end the filters rest directly upon this chalk foundation, but at their south end they rest on the arched roofs of the reservoirs. These arched roofs are of concrete resting in turn on brick walls running north and south in the reservoirs and spaced about every 16 ft. To save weight and material the brick walls are arched as shown in Fig. 2. The divisions between the adjacent filter beds and also between the adjacent reservoirs are made by heavy concrete walls (Fig. 3), laid up inside of a brick facing, afterward covered with a 1-in. cement coating. The bricks were used here because it was thought they would give a better line than timber forms and because also they make a better base to which to apply cement grout.

Those parts of the new reservoirs which are outside of the filter beds and all of the old reservoirs, are covered with a reinforced-concrete roof resting on concrete columns.

The seven filter beds are each about half an acre in superficial area, and each contains 3 ft. of sand over 9 ins. of gravel carried on a loosely-laid brick bottom. The raw water enters at the north end of each bed and after passing through the sand runs into a collecting trough in the middle of each bed out into the 30-in. main and thence into the reservoirs. The total filtering capacity of the plant is 12,000,000 Imp. gals. a day. Each of the two new reservoirs measures 360 × 160 ft. and contains 13 ft. 6 ins. depth when full. The line of mains and the direction of the flow is shown on Fig. 1.

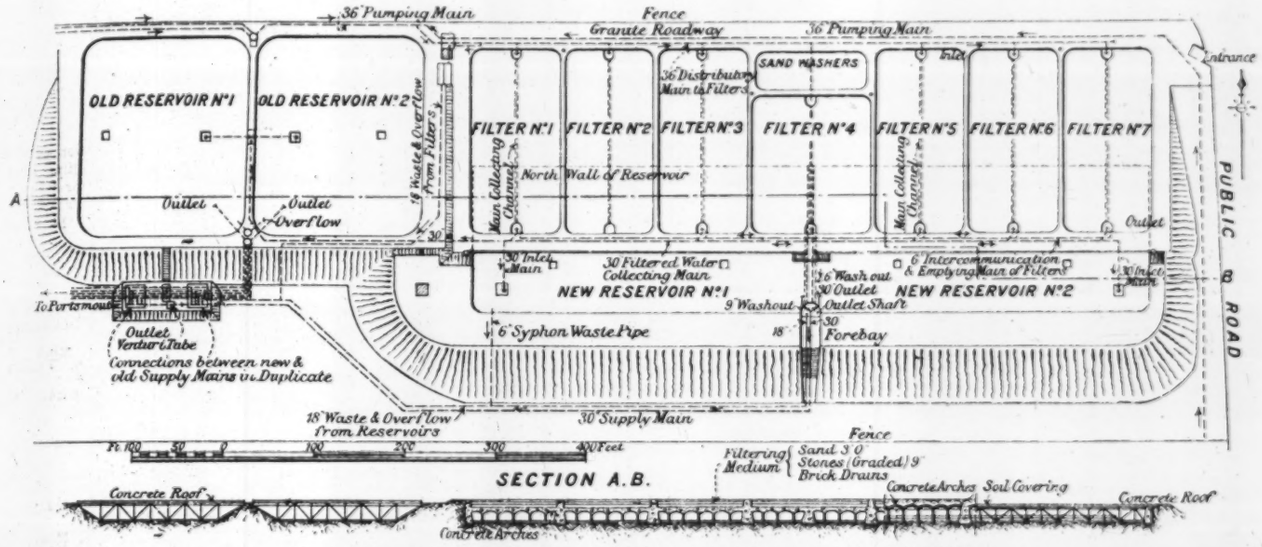


FIG. 1. PLAN OF THE FILTERS AND RESERVOIRS AT PORTSMOUTH, ENG.

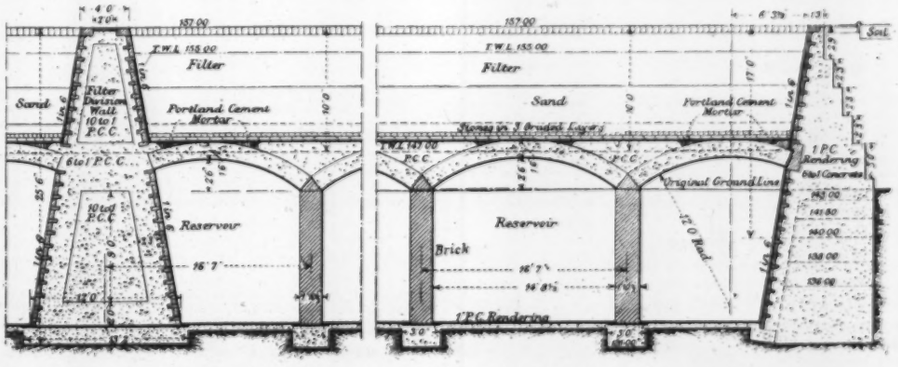


FIG. 3. DETAILS OF RESERVOIR WALLS WITH FILTERS ABOVE.

AN IMPORTANT COURT DECISION ON NEGLIgence was rendered on Dec. 1 by Judge Buffington, of the United States Appellate Court at Philadelphia, in connection with a civil suit resulting from the collapse of a building under reconstruction at 11th and Market Sts., Philadelphia, on July 15, 1909. As reported in our issue of July 22, 1909, p. 107, the building was under lease by the United States Gas Improvement Co., which company had let a contract to a firm of builders for extensive alteration. This firm had sublet to another firm the work of shoring up the upper stories while the first floor and basement were being changed according to new plans. On July 13, 1909, one or more of the shores collapsed, carrying down the whole upper part of the building and causing the death of six workmen and the serious injury of 17 others. A civil suit for damages was soon instituted by the widow of one of the deceased workmen against the lessees of the building, the United Gas Improvement Co. In a lower court a jury awarded damages to the widow to the amount of $3,000, her counsel claiming the right to recover on the ground that despite the fact that the work of altering the building was let out under contract, the United Gas Improvement Co. was in charge of the work and was therefore responsible for any accidents that occurred. The case was carried to the higher court and, hearing that appeal, Judge Buffington found that although the United Gas Improvement Co. was the lessee of the building when it collapsed, it had a contract with a construction company, which practically transferred to the contractor possession of the building, and gave to the lessee no right to dictate as to the means of performing the work, but only em-

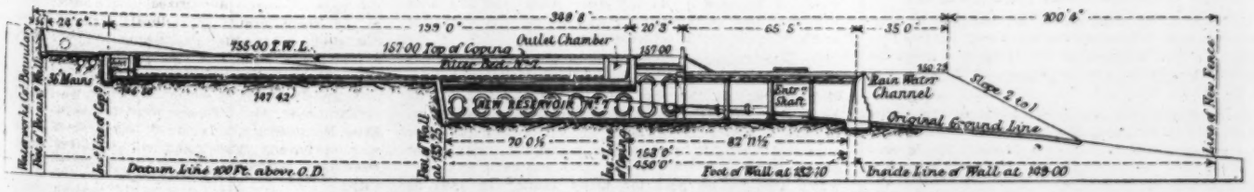


FIG. 2. TRANSVERSE SECTION THROUGH FILTERS AND NEW RESERVOIRS.

powered it to insist that the building be completed as provided in the plans and specifications. The opinion further holds that the United Gas Improvement Co. took no part in conducting the work, and did not interfere in any way with its prosecution. As a result of this reasoning the court held that the United Gas Improvement Co. is not liable for damages and reversed the findings of the lower court.

A METEOR HIT A GRAIN ELEVATOR at Beaver City, Neb., Dec. 9, according to a report in the Omaha "Bee." The elevator was burned to the ground together with its 1,900 bushels of grain.

THE STEAMER "OLYMPIA," of the Alaska Steamship Co.'s line, went on the rocks at Bligh Island, Prince William Sound, in the storm of Dec. 11. The passengers and crew, 123 persons in all, were rescued by launches sent out from towns on the Alaskan coast in response to wireless calls from the wreck. It is reported that the cargo can also probably be saved but that the ship itself will be a total loss.

A LIGHT ENGINE ON THE WRONG TRACK collided head-on with a passenger train on the Grand Trunk Ry. Dec. 10 near St. Hyacinthe, Que. Four trainmen were killed and seven others badly injured. The railway is double-tracked at the place where the collision occurred. The light engine had for some unexplained cause taken the wrong track upon passing from the single to the double-track line at Ste. Rosalie Junction. The accident occurred at night and the engineers, according to reports, did not discover until too late that they were on the same track.

A COAL MINE DISASTER in the Bellevue mine of the West Canada Collieries, Limited, imprisoned 35 men Dec. 9. The explosion occurred at 7 p. m., after the day shift had left the mine. Reports state that 45 dead bodies have been recovered by rescue parties. The explosion is ascribed to the revival of a fire which broke out in the mine Nov. 24 and which it was thought had been extinguished. The mine had been in operation several days, however, since it was reopened after the supposed extinguishment of the fire.

A DERRICK BOOM FELL in New York City, Dec. 13, at the excavation for the Woolworth Building at Broadway and Park Place. The topping-lift rope broke while a light load of dirt and rock was being hoisted. The end of the 50-ft. boom cut through the fence that screens the excavation from the temporary wooden sidewalk and struck the heads of a man and a boy who were passing. The man was killed and the boy fatally injured. The cable is reported to have been a new one in use only about one week.

PROPOSAL ADVERTISEMENTS FOR THE CITY aqueduct tunnel of the new Catskill water-supply system of New York City have been withdrawn. It is stated that the form of contract lacked the approval of the City Corporation Counsel, which is a legal requirement of advertising for bids. Mayor Gaynor intervened in the matter, and unverified reports are to the effect that the contract requirements as well as the handling of specifications and data were such as to militate against securing full and free competition in bidding. The chairman of the Board of Water Supply, Mr. J. A. Bensel, has been elected to the office of State Engineer and assumes his new duties on Jan. 1, 1911.

Personals.

Mr. William Michel, formerly Engineer of Maintenance-of-way of the Hocking Valley Ry., has been appointed Chief Engineer of the same road.

Mr. James A. Bell, M. Can. Soc. C. E., has resigned as City Engineer of St. Thomas, Ont., after 25 years' service in order to devote his whole time to private practice.

Mr. William C. Henning has resigned as President and Treasurer of the Durable Wire Rope Co., of Boston, Mass., to become Secretary and Treasurer of the A. Leschen & Sons Rope Co., of St. Louis, Mo.

Mr. C. H. Doebler, recently with the Galena Signal Oil Co., of Franklin, Pa., and formerly Master Mechanic on the Wabash R. R., has been appointed Master Mechanic for the Chesapeake & Ohio Ry. at Peru, Ind.

Mr. J. S. Dennis, M. Can. Soc. C. E., Assistant to Vice-President William Whyte of the Canadian Pacific Ry., has been appointed Manager of the company's irrigation and land interests in the provinces of Alberta and British Columbia.

Mr. A. R. Manderson, Master Mechanic of the Maine Central R. R. at Portland, Me., has been promoted to Assistant Superintendent of Motive Power. He is succeeded as Master Mechanic by Mr. H. A. Southworth, Division Foreman at Waterville.

Mr. John Hays Hammond, M. Am. Inst. M. E., is in Russia, in the interest of American capitalists, to investigate the possibilities for investments in the construction of irrigation works, lighting and street car service and other public utilities.

Mr. Lawrence A. Downs, Assistant Engineer of Maintenance-of-way of the Illinois Central R. R. at Chicago, Ill., has been appointed Superintendent with headquarters at Fort Dodge, Ia., succeeding Mr. George W. Berry, who has been transferred.

Mr. Chester W. Smith, Assoc. M. Am. Soc. C. E., has resigned from the U. S. Reclamation Service. Mr. Smith entered the service in December, 1904, and from that time has been in charge of construction on the Roosevelt Dam, Salt River Project, Arizona.

Mr. Arthur H. Blanchard, M. Am. Soc. C. E., Associate Professor of Civil Engineering at Brown University, Providence, R. I., and Consulting Highway Engineer, has been appointed Expert and Consulting Engineer to the United States Office of Public Roads.

Mr. W. J. Cunningham, of the staff of the Assistant General Manager of the New York Central Lines at Boston, Mass., has been appointed Assistant Professor of Economics at Harvard University. Mr. Cunningham will retain his connection with the railroad company.

Mr. Irving W. Patterson, Jun. M. Am. Soc. C. E., has resigned as Resident Engineer with the State Board of Public Roads of Rhode Island to become Assistant Engineer with Mr. Arthur H. Blanchard, M. Am. Soc. C. E., Consulting Highway Engineer, Providence, R. I.

Mr. Martin A. Knapp, Chairman of the Interstate Commerce Commission, has been nominated Chief Justice of the newly created Court of Commerce by President Taft. The nominations for the other four justices are: Messrs. Robert W. Archbold, now United States District Judge for the middle district of Pennsylvania; William H. Hunt, now a Judge of the Court of Custom Appeals; John E. Carland, of South Dakota, and Julian W. Mark, now Judge of the Appellate Circuit Court of the First Illinois District.

Obituary.

Robert Hollingsworth, Chief of the Camden, N. J., Water Department, died at the Presbyterian Hospital in Philadelphia on Dec. 9. Mr. Hollingsworth had been the head of the water bureau for the past six years.

Frederick C. Ely, a director of the Pressed Steel Car Co. and prominent for many years in the railway supply business, died in New York City on Dec. 12. He was born in Watertown, N. Y., on Aug. 2, 1838, and was a brother of Mr. T. N. Ely, Chief of Motive Power of the Pennsylvania R. R.

Walter L. Pierce, Assoc. Am. Soc. M. E., for many years Secretary and General Manager of the Lidgerwood Mfg. Co., died in New York City on Dec. 10. He was 55 years old and leaves one son, Walter L. S. Pierce. He was also an Associate of the Society of Naval Architects and Marine Engineers, and a member of the Engineers' Club of New York City, and the Machinery Club.

Cooper D. Schmidt, Professor of Mathematics at the University of Tennessee, died at his home in Knoxville, Tenn., on Dec. 6. He had been found in one of his recitation rooms in an unconscious condition and died four hours later without regaining consciousness. He was 51 years of age and was Dean of the College. He was a graduate of Mercersburg College and the University of Virginia.

E. V. W. Rossiter, Vice-President of New York Central & Hudson River R. R., died at his home in Flushing, L. I., on Dec. 11. He was born at St. Louis, Mo., on July 13, 1844. He entered the railway service at the age of 15 as a clerk in the President's office of the Hudson River Rd. He served continuously with this road and its successors until the time of his death. He had been Vice-President since 1900.

John Rogers Maxwell, Chairman of the Executive Committee of the Central R. R. of New Jersey, and formerly President of the Atlas Portland Cement Co., died from cerebral apoplexy at his home in Brooklyn, N. Y., on Dec. 11. He was 64 years old. He was born in New York City, but his home for many years had been in Brooklyn, where he attended the public schools and the Brooklyn Polytechnic Institute, of which he was a trustee at the time of his death. He was prominent in railway circles as a director of the Delaware, Lackawanna & Western R. R. and other roads, and had been Vice-President of the Long Island R. R., and President of the Central R. R. of New Jersey.

Benjamin Silliman Church, one of the designers of the Croton Aqueduct of the New York City Water Supply, died on Dec. 10. He was born at Belvidere, N. Y., on April 17, 1833, of distinguished New England ancestry. In 1856 he graduated from Dartmouth College and after a course in civil engineering became a topographer on the Croton Aqueduct, and later Resident Engineer, which position he held for many years. In 1880 he invented an apparatus for detecting water waste in private houses, during the night, by an attachment to the street connection.

Mr. Church became Chief Engineer for the Aqueduct Commissioners in 1883 and held this position until 1888, when he resigned. He continued as Consulting Engineer for the Commission until 1889. He was for many years a member of the American Society of Civil Engineers and a contributor to the Transactions of the Society.

Engineering Societies.

COMING MEETINGS.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at St. Paul, Minn. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-28. Annual meeting at Lafayette, Ind. Secy., E. W. Hamilton, Iowa State College, Ames, Iowa.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 2-6. Annual meeting at Winnipeg, Man. Secy., C. H. McLeod, 413 West Dorchester St., Montreal, Que.

INDIANA ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Indianapolis, Ind. Secy., Charles Brossmann, Indianapolis, Ind.

MONTANA SOCIETY OF ENGINEERS.
Jan. 12-14. Annual meeting at Helena, Mont. Secy., Clinton H. Moore, Leyson Block, Butte, Mont.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 17. Annual meeting at Pittsburg, Pa. Secy., Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 17-19. Annual convention at San Francisco, Cal. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 18-19. Annual meeting at New York City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Jan. 20. Annual meeting at New York City. Secy., P. S. Millar, 29 West 39th St., New York City.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 24-26. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

OHIO ENGINEERING SOCIETY.
Jan. 24-26. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 25-27. Annual meeting at East St. Louis, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 6-11. Annual convention at Louisville, Ky. Secy., T. A. Randall, Indianapolis, Ind.

NEW YORK ELECTRICAL SOCIETY.—At the meeting of Dec. 14, Mr. Charles N. Chadwick, Commissioner of the Board of Water Supply of New York City, gave an address on "The Catskill Water Supply."

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At a meeting of the general section Dec. 8 at Montreal, Que., a paper was presented on "A New Water Supply for the City of Vancouver, B. C.," by H. M. Burwell.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The proposed excursion to Panama has been definitely decided upon. One party is to sail from New York City March 2, 1911, and a second party will leave New Orleans, La., March 4. The trip will be made on the steamers "Zacapa," from New York, and "Abangarez," from New Orleans. Both vessels are due at Colon, Panama, March 9.

THE INVENTORS' GUILD was organized recently in New York City to improve the unsatisfactory conditions of the U. S. Patent Office. Among the first objects of the Guild are the installation of the Patent Office in a suitable fireproof building, the employment of an adequate force of patent examiners, and the investigation and reform of legislation affecting patents and patent infringement. The officers elected are as follows: President, R. D. Mershon; Vice-Presidents, C. W. Hunt and Charles S. Bradley; Secretaries, Thomas Doherty; Board of Governors, Peter Cooper Hewitt, Prof. M. I. Pupin, of Columbia University; Prof. Northrup, of Princeton; Prof. Carl Thomas, of the University of Wisconsin, and Prof. Pierce, of Harvard. The membership is at present limited to 50.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The Council of the Society has elected Dr. Alex. C. Humphreys, President of Stevens Institute, Hoboken, N. J., a Vice-President of the Society to fill the vacancy caused by the election of Col. E. D. Meier to the Presidency at the annual meeting of the society last week. Col. Meier was elected a Vice-President only a year ago and had one year still to serve.

A meeting under the joint auspices of this society and the Engineers' Club of St. Louis was held Dec. 10 at St. Louis, Mo. Papers were presented on "Modern Shoe Manufacture," by M. B. Kaven and J. P. Hadaway, of Beverly, Mass., and on "Operating Conditions of Passenger Elevators," by R. P. Bolton, of New York City.